

ORDINANCE NO. 1883

**AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF MILWAUKIE,
OREGON, ADOPTING THE WATER SYSTEM MASTER PLAN.**

WHEREAS, Oregon Administrative Rules (OAR) 333-061-0060 (5) (a) requires community water systems with 300 or more service connections to maintain a current master plan that is reviewed and approved by the Oregon Health Division; and

WHEREAS, the City of Milwaukie desires to be in compliance with the Oregon Administrative Rules (OARs); and

WHEREAS, the City of Milwaukie selected Montgomery Watson, a consulting engineering firm, to prepare a Water System Master Plan to meet the requirements of the Oregon Administrative Rules ; and

WHEREAS, the Oregon Health Division has reviewed and approved the Water System Master Plan; and

WHEREAS, the City Council held a duly advertised Public Hearing on February 20, 2001.

**NOW, THEREFORE, THE CITY OF MILWAUKIE DOES ORDAIN AS
FOLLOWS:**

Section 1. Findings. The Master Plan evaluates the needs of the City's water system for at least a fifteen year period and includes the following elements:

A. A summary of the overall plan that includes the water quality and service goals, identified present and future water system deficiencies, the engineer's recommended alternative for achieving the goals and correcting the deficiencies, and the recommended implementation schedule and financing program for constructing improvements.

B. A description of the existing water system which includes the service area, sources of supply, status of water rights, current status of drinking water quality and compliance with regulatory standards, maps or schematics of the water system showing size and location of facilities, estimates of water use, and operation and maintenance requirements.

C. A description of water quality and level of service goals for the water system, considering, as appropriate, existing and future regulatory requirements, nonregulatory water quality needs of water users, flow and pressure requirements, and capacity needs related to water use and fire flow needs.

D. An estimate of the projected growth of the water system during the master plan period and the impacts on the service area boundaries, water supply sources and availability, and customer water use.

E. An engineering evaluation of the ability of the existing water system facilities to meet the water quality and level of service goals, identification of any existing water system deficiencies, and deficiencies likely to develop within the master plan period. The evaluation shall include the water supply source, water treatment, storage, distribution facilities, and operation and maintenance requirements. The evaluation also included a description of the water rights with a determination of additional water availability, and the impacts of present and probable future drinking water quality regulations.

F. Identification of alternative engineering solutions, environmental impacts, and associated capital and operation and maintenance costs, to correct water system deficiencies and achieve system expansion to meet anticipated growth, including identification of available options for cooperative or coordinated water system improvements with other local water suppliers.

H. A recommended water system improvement program including the recommended engineering alternative and associated costs, maps or schematics showing size and location of proposed facilities, the recommended financing alternative, and a recommended schedule for water system design and construction..

Section 2. Adoption. The City of Milwaukie "Water System Master Plan" dated January 2001 and authored by Montgomery Watson is hereby adopted .

Read the first time on February 20, 2001, and moved to second reading by unanimous vote of the City Council.

Read the second time and adopted by the City Council on February 20, 2001.

Signed by the Council President on February 20, 2001.



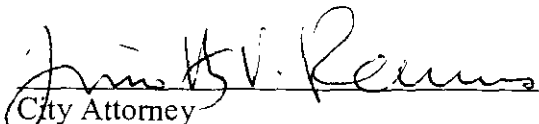
Mary King, Council President

ATTEST:

APPROVED AS TO FORM:
Ramis, Crew, Corrigan & Bachrach, LLP



Pat DuVal, City Recorder



City Attorney



MILWAUKEE

City of Milwaukee

Water System Master Plan Executive Summary

January, 2001



MONTGOMERY WATSON

EXECUTIVE SUMMARY

Introduction

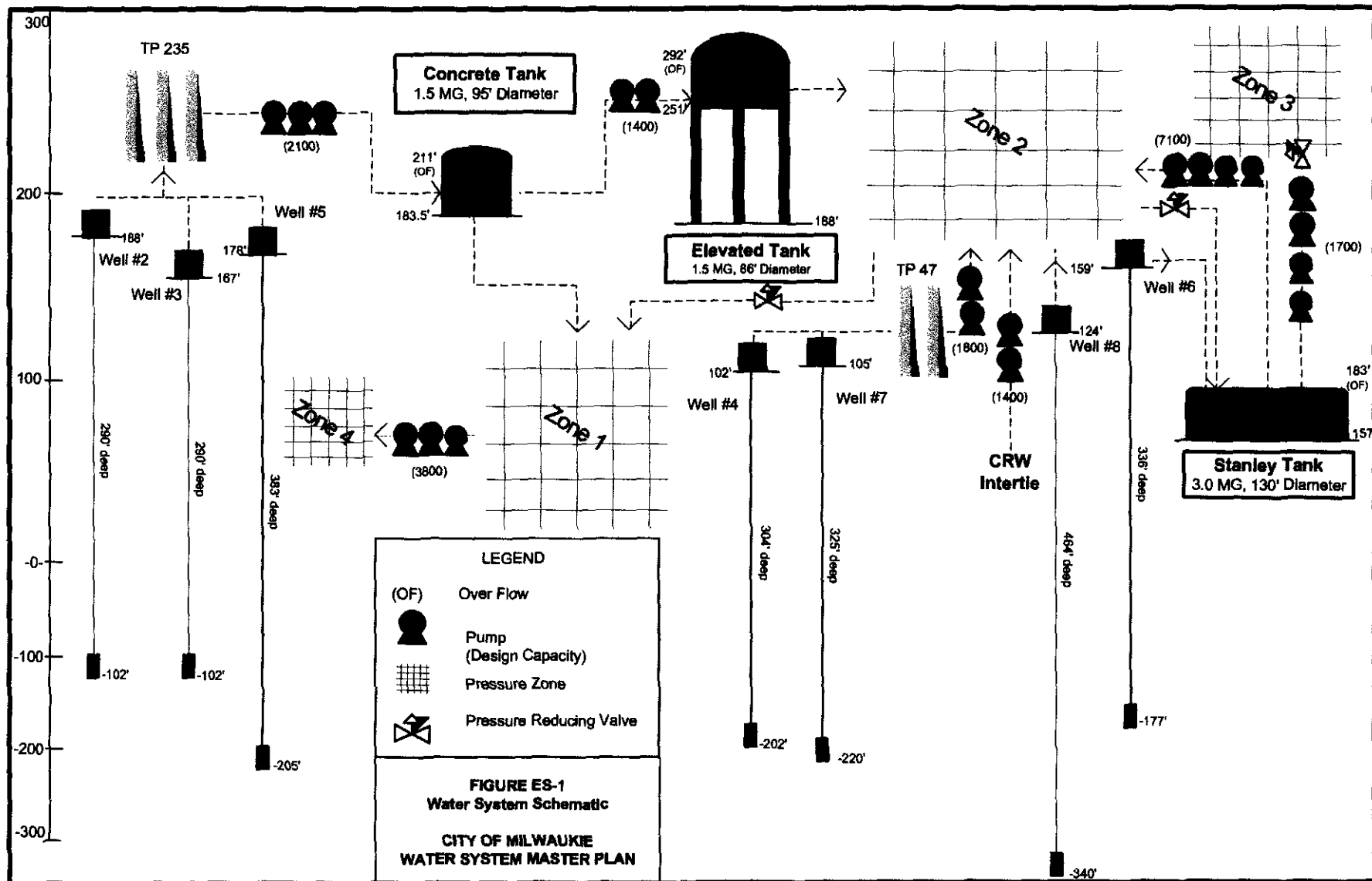
The City of Milwaukie provides about 5.8 million gallons a day (mgd) of water supply through a system of groundwater wells tapping the Troutdale Aquifer. Since August 1998, the City has supplemented its groundwater supply by purchase of approximately 0.5 mgd of surface water from Clackamas River Water (CRW). The City's water system includes approximately 100 miles of distribution and transmission pipelines, three reservoirs totaling 6.0 million gallons in storage, a pumping station, pressure reducing valves, and other facilities. A schematic of the City's water system is shown in Figure ES-1.

This Master Plan has been prepared to meet the requirements of the Oregon Health Division's (OHD) drinking water regulations and in partial fulfillment of the requirements of Goal 11, Public Facilities and Services, of the State of Oregon land use program. This Goal requires the City "to plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development".

The major elements of the scope of work for this Water System Master Plan were to:

- Review and develop new forecasts of population and water demands,
- Develop planning criteria to be used in evaluating the existing system and future system expansions,
- Evaluate the existing system for deficiencies compared to the planning criteria,
- Develop a source of supply strategy;
- Identify the system improvements needed to support anticipated growth and development and provide means to anticipate system improvements before growth is constrained, and
- Prepare a Capital Improvement Program based on the evaluation of existing and future facilities,

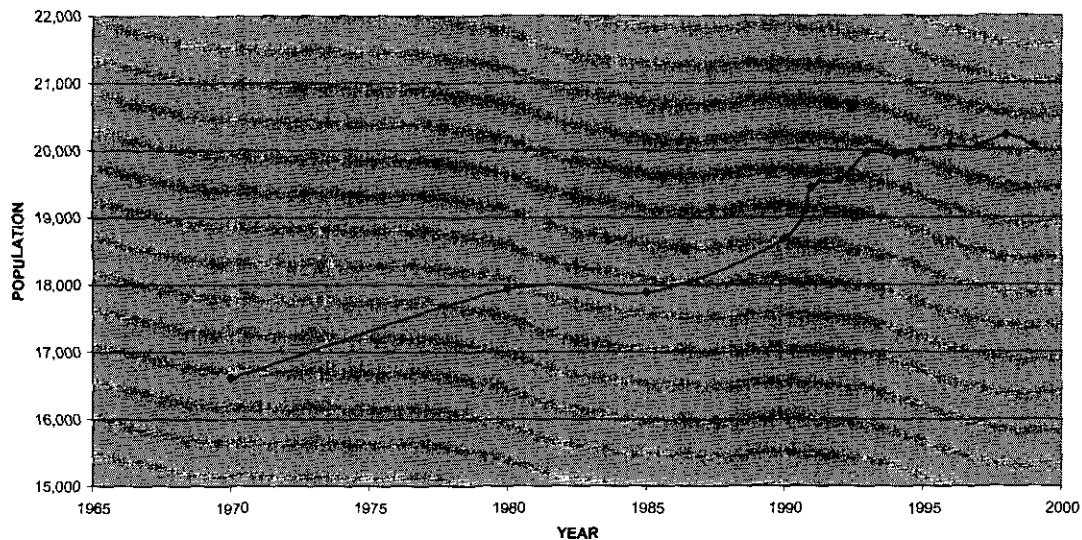
Determining water system rates or financing mechanisms was not a part of the Scope of Work for this Master Plan.



Population Forecast

Water demand forecasts require the estimation of two key parameters - the population that is to be served and the amount of water that population is likely to consume. Population trends over the decades since 1970 are illustrated in Figure ES-2. Population growth slowed significantly in Milwaukie in the early 1980's, in response to the state recession. Growth increased rapidly in the early 1990's and the City has been growing by an average of 0.8 percent per year since that time.

**FIGURE ES-2
MILWAUKIE HISTORICAL POPULATION ESTIMATES**



A number of potential sources and methodologies for forecasting the future population growth for the City are available. These include previous studies, figures from METRO, projections based on historical rates of growth, and the City's own Comprehensive Plan forecast that was adopted in 1999. These estimates are all fairly comparable.

Because the City's Comprehensive Plan forecast incorporates the most rigorous analysis of future development within the City that is currently available, it was used as the basis for population growth for this Master Plan. Based on this forecast, **the assumed total population served at build out will be 27,950 people**. It is also assumed that build out will occur by the year 2015. This number assumes that the City will fully annex Dual Interest Areas A and B, which are unincorporated areas contiguous to the current City boundaries.

Water Demand Forecast

Water demand refers to all the water requirements of a water system including domestic, commercial, municipal, irrigation, institutional and industrial as well as unbilled, unmetered and unaccounted-for water. Demands are discussed in terms of gallons per unit of time such as million gallons per day (mgd). Demands are also related to per capita use in gallons per capita per day (gpcd).

Water demand projections in a Master Plan must be large enough so that the facilities that are being planned will be adequate to cover future water needs in the community. At the same time, the demand forecast must not be too large, as then the planned facilities will also be too large and unnecessarily expensive. The balance between these two concerns must be found. It is important to understand that water demand projections are for planning purposes only. The final sizing and capacity of the recommended facilities should be evaluated and reviewed during individual project predesign to determine their appropriate sizing and other design criteria.

Predicting future water use has several inherent uncertainties. Per capita consumption in a community is influenced by many factors and can vary widely even between adjacent neighborhoods. Table ES-1 illustrates this fact for the City of Milwaukie. It shows historical water production figures for the years 1991 to 1998. Annual, maximum monthly and maximum daily production data and per capita consumption are shown in this Table. These figures include demand exerted by large portions of Area A, even though most of this area has not yet been annexed into the City. Some demand is also being exerted by Area B, although much of this area is currently being served by Clackamas River Water (CRW).

TABLE ES-1
HISTORICAL WATER DEMANDS WITHIN MILWAUKIE CITY LIMITS

YEAR	POPULATION	ANNUAL AVE DEMAND, MGD	MAX MONTHLY DEMAND, MGD	MAX DAILY DEMAND, MGD	RATIO OF MAX TO AVE ANNUAL DEMAND		PER CAPITA DEMAND		
					MAX MONTHLY	MAX DAILY	AVERAGE	MAX	MAX
							ANNUAL gpcd	MONTHLY gpcd	DAILY gpcd
1991	19,450	2.65	4.1	5.27	1.5	2.0	136	211	271
1992	19,550	2.68	3.96	5.74	1.5	2.1	137	202	294
1993	19,955	2.56	3.14	4.61	1.2	1.8	128	157	231
1994	19,930	2.67	4.23	5.41	1.6	2.0	134	212	271
1995	20,015	2.59	3.53	4.00	1.4	1.5	129	176	200
1996	20,065	2.75	3.91	4.89	1.4	1.8	137	195	244
1997	20,055	2.54	3.97	4.92	1.6	1.9	127	198	245
1998	20,220	2.47	3.87	5.14	1.6	2.1	122	191	254
1999	20,075	2.52	3.45	4.50	1.4	1.8	126	172	224

note: original data was not provided for years 1991, 1992. Figures taken from 1993 Water Source/Demand Study

As can be seen in Table ES-1, the peak day per capita consumption in Milwaukie varies considerably over this period, from a low of 200 gpcd to a high of almost 300 gpcd. This large a variation in peak demand over an eight year period of record is not uncommon in most communities. For comparison purposes, the peak day per capita consumption over the same period for Oregon City varied from 285 to 381 gpcd, and for the City of West Linn it ranged between 249 to 335 gpcd.

As can be seen by comparing Milwaukie with its neighboring cities, Milwaukie's per capita consumption was at the low end of the range observed in surrounding small cities. This low per capita usage reflects Milwaukie's character as an older, fully developed community. In newer, more rapidly growing communities, residential construction, development and irrigation are major water users. Milwaukie's per capita consumption figure is consistent with an established city, and is more similar to that observed in the City of Portland.

While the peak day per capita consumption can vary significantly from year to year due to the weather, there tends to be an upper limit in a community to the per capita consumption. Based on the distribution of the citywide values, it would not be unreasonable to expect peak day per capita consumption values up to approximately 5% higher than shown in Table ES-1 under extreme weather conditions. Thus, the citywide peak day per capita consumption could reach 300 gpcd in an extremely hot year.

For the purposes of this plan, it is recommended that 280 gpcd be used for peak day consumption for the year 2015 demand projection. This figure is at the high end of historically observed per capita consumption, and provides some system reliability to accommodate hot and dry weather. It also reflects Milwaukie's status as a stable, developed community that will grow mostly by redevelopment and infill over the next 15 years. **It is also recommended that the future average daily per capita demand be assumed to be 140 gpcd.** The peaking factor, defined as the ratio of average to peak daily demand then becomes 2.0, which is a reasonable and commonly used peaking factor, and is consistent with historical records for the City of Milwaukie.

The future water demand forecast is obtained by multiplying the recommended per capita usage rate by the recommended population forecast. The results of this calculation are shown in Table ES-2. It must be recognized that these estimates are predictions based on the best information available at this time, and should be subject to continuous updating and adjustment based on the actual water demand that the City experiences over time.

**TABLE ES-2
CITY OF MILWAUKIE
SUMMARY OF PROJECTED WATER DEMANDS**

YEAR	2015/Buildout
POPULATION	27,950
PEAK DAY PER CAPITA CONSUMPTION (GPCD)	280
AVERAGE DAY PER CAPITA CONSUMPTION (GPCD)	140
AVERAGE DAILY DEMAND (MGD)	3.91
PEAD DAY DEMAND (MGD)	7.83

Planning Criteria

Development of recommendations in this Water System Master Plan depend upon establishment of planning and analysis criteria which are used to evaluate the existing facilities and plan for new facilities. It must be recognized that these planning criteria are not hard and fast rules that must be exactly adhered to in order to provide a reliable water system. They are simply standards by which the system can be judged for the purposes of planning capital improvement and capital maintenance projects under most circumstances. The criteria that have been used in this Master Plan include:

Planning Period. This Water System Master Plan covers a 15-year period to the year 2015. This corresponds to the year of projected ultimate buildout for the City.

Planning Area. The planning area for the Master Plan is the limit of the current City of Milwaukie water system, plus Dual Interest Areas A and B. It is assumed that these areas will be annexed and fully developed by the year 2015, and that the City of Milwaukie will provide water service to these areas.

Service Pressure. The minimum pressure that must be maintained in the system per State of Oregon Health Division standards is 20 pounds per square inch (psi). This pressure must be maintained even during a fire flow event on a peak demand day. The typical operating pressures that are currently obtained from the existing tanks and reservoirs of between 45 psi and 170 psi should be maintained.

Source. The main source of supply should be capable of providing the projected peak day demand. It should meet this demand with firm capacity - that is, with the largest pump, filter or other component of the system out of service. The City should also have an emergency source of supply that is capable of providing the average day demand for the length of time that the primary source of supply is out of service, such period lasting up to a week. This emergency source could be provided through an intertie, storage, a secondary source, or other methods.

Transmission Pipelines. Transmission pipelines are considered as those greater than or equal to 10-inches in diameter. Pipeline flow velocities in transmission pipelines should be less than 5 feet per second. All water transmission pipelines greater than or equal to 18-inches in diameter should be capable of providing peak day demands. All other transmission pipelines should be capable of supplying peak hour demands.

Distribution Pipelines. Distribution pipelines should be sized to serve peak hour demands and fire flow requirements. Flow velocities for a distribution system pipeline should be below 10 fps and headloss in the pipeline should be below 10 ft per 1000 ft of pipeline. Minimum pipeline diameter for new distribution pipes will be 6-inches in diameter. Any pipeline below 6-inches should be upgraded before being equipped with a fire hydrant. A 6-inch line with a fire hydrant should be part of a looped system or be no more than 500 feet in length.

Pump Stations. Pump stations should be sized for a firm capacity equal to the peak day demand. For reliability, power supplies to pump stations should have either two sources of primary power feed, or one main source and standby or emergency power. The secondary power supply should be sized so that available pumping capacity is equal to average day demand, or fire flow, whichever is greater.

Storage. Storage facilities in water systems are generally provided for four purposes - equalization storage, operational storage, fire storage, and emergency storage. The total storage required in any tank or reservoir is the sum of these four components plus the dead storage (the volume of the tank that is unavailable to use due to physical constraints).

Equalization storage is needed in a water system to meet water system demands in excess of the transmission/pumping delivery capacity from the supply source to the reservoir. A value of 25 percent of peak day demand is recommended for equalization storage. Operational storage may be needed if the supply source does not continuously deliver

supply. The City of Milwaukie, however, does not operate its distribution system in a manner that requires additional operational storage beyond equalization storage, and thus, no additional operational component of storage is recommended in this Master Plan.

Fire storage is provided to meet the single most severe fire flow demand within the system or pressure zone served by the storage facility. The fire storage volume required is determined by multiplying the fire flow rate by the duration of that flow.

Residential fire flows are 1000 gpm for 2 hours and can be applied at any fire hydrant in the pressure zone. Commercial, industrial, and multi-family fire flows can be applied at any fire hydrant within areas that have appropriate land use zoning and may be specific to the zoning and actual facilities in place. A fire flow of 5,000 gpm for 10 hours is a conservative upper limit on storage requirements for zones with commercial, industrial and multi-family uses.

Emergency storage is provided to supply water from storage during emergencies such as power outages, equipment failures, pipelines failures or natural disasters. The amount of emergency storage provided can be highly variable and is dependent upon an assessment of risk and the desired degree of system reliability. An emergency supply equal to one day of average demand within a pressure zone is considered typical for most distribution systems and is appropriate for the City of Milwaukie's system.

It is also desirable, although not required, that storage be provided from at least two separate storage reservoirs or is available through pumping or gravity from a secondary reservoir at a different elevation. This provides for continuous operations during maintenance, repairs or reconstruction or modifications to any single reservoir.

Based on the above criteria, the total recommended required storage in each pressure zone will consist of 25% of projected peak day demand for equalization plus the fire flow demand plus one average day demand for emergencies. This is comparable to the storage requirements set forth in previous studies that the City has conducted.

Key Findings of the System Evaluation

The City's existing water system was evaluated in several ways in this Master Plan. These methodologies were field inspection of key facilities; a comparison of key facilities to the planning criteria; the development of a hydraulic model of the system; and a review of other data, information, and records in the City's files.

The Need for Additional Supply. As indicated in the planning criteria, the water system should be able to meet peak day demand with the largest single component of the supply out of service. The total current capacity of the City's groundwater source is 5.8 mgd and the current capacity of its surface supply from CRW is 0.5 mgd. This provides a total production of 6.3 mgd. The largest component of the supply system is Well No. 7, at 1.4

mgd. If this component is out of service, the resultant firm supply capacity is 4.9 mgd. This firm capacity is well below the projected peak day demand in 2015 of 7.8 mgd. Using a straight-line projection, projected peak day water demands will outstrip firm capacity by 2002, and will surpass ultimate production capacity by the year 2008. Therefore, it is recommended that 3 mgd of additional firm source capacity be acquired.

The Source of New Supply. The City has two basic alternatives to develop additional supply – to increase its groundwater production by the development of new wells, or to increase its purchase of surface supply from surrounding water providers. In the latter case, potential water providers are the City of Portland, Clackamas River Water (CRW) and the Oak Lodge Water District. The Oak Lodge Water District was eliminated from consideration after preliminary discussions with them indicated that it is not an option for the time period of this Master Plan. The remaining three alternatives were evaluated in more detail. The evaluation considered qualitative criteria and relative comparisons of costs. The qualitative criteria that were considered were:

- Certainty of Supply.
- Water Quality.
- Reliability.
- Ease of Implementation.
- Consistency with local and regional planning.
- Compatibility with existing facilities.
- Ownership and Agreements.

Cost considered capital, operating and maintenance costs.

The CRW and groundwater options were similar in cost, at about \$3.4 million over the life of the Master Plan. The City of Portland option was \$5.2 over the same period. The qualitative evaluation favored the CRW option. It ranked high on all the qualitative criteria and its use diversifies the City's sources and strengthens its emergency interconnections.

Water conservation was considered in this Master Plan as a method of delaying the need for additional water supply. It is important to note that current water demands in the City of Milwaukie already reflect conservation which has occurred in the region since the 1992 drought. The Portland Water Bureau estimates that a reduction in demand of 10 to 15 percent has occurred throughout the region in response to actions taken by water providers in 1992 and subsequent years. Milwaukie experienced a high per capita demand in the drought year of 1992 of 294 gpcd. Although there was a small spike upward in 1994 (another drought year), per capita consumption has so far not climbed back up to 1992 levels. In 1998/1999, per capita consumption was still 85 percent of the 1992 consumption rate. This suggests that conservation messages and practices continue to have an effect on consumption. By 2015, peak day demand is projected to reach 7.3 million gallons per day. This is a 50 percent increase over 1998/1999 peak day demands,

and will be fueled by population growth. Water conservation cannot replace the need for additional supply at these levels, but it may be able to affect the timing of necessary improvements. Conservation is therefore an important element of the City's overall water supply strategy.

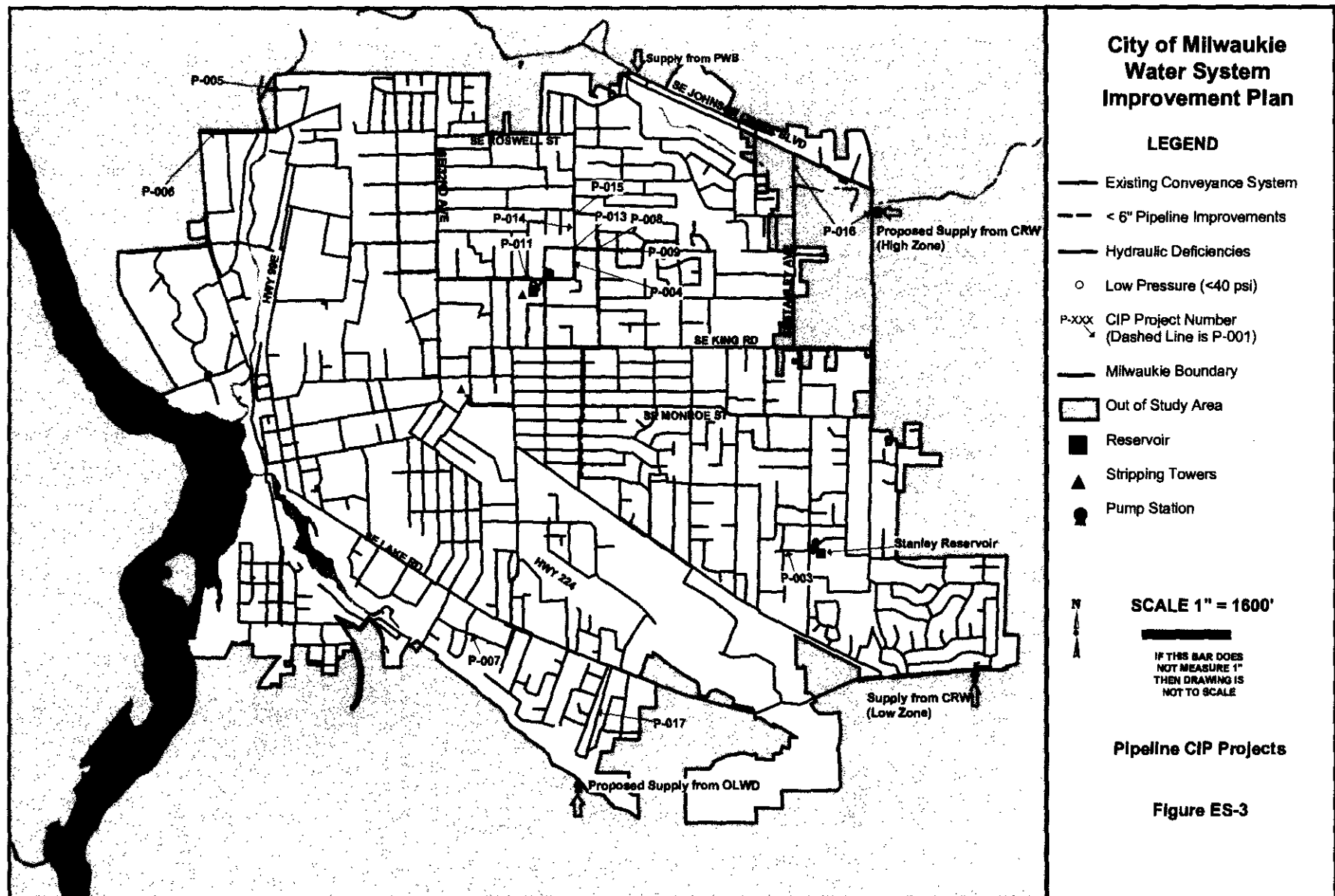
To further strengthen emergency water supply, it is recommended that the City develop emergency interties and emergency supply agreements with its other neighboring water providers, the City of Portland and the Oak Lodge Water District. The City of Portland intertie is already under development. A previous intertie with the Oak Lodge Water District that is now inoperable should be reactivated.

New Storage. The City currently maintains 6 million gallons (MG) of storage in three reservoirs. Based upon the planning criteria for storage, the City needs an additional 1.5 MG of storage to serve its current population. This storage deficit will grow to 2.5 MG at buildout. Ideally, storage for each pressure zone would be provided from a reservoir that feeds that zone via gravity. However, the topography and location of reservoir sites in the City of Milwaukie has required that much of the City's existing storage be provided through pumping from lower elevations.

Several options for new storage were investigated in this Master Plan. The most economically favorable option to the City is joint storage with CRW at the site of their existing Otty Road Reservoir complex. CRW currently has excess storage capacity available at that site and can build more storage over time to accommodate growth for Milwaukie and CRW. Water stored at that site is of an elevation that allows for its use by gravity. Use of this site for storage also integrates with the recommendation for a new source of supply from CRW at this location. The Master Plan recommends pursuing joint storage with CRW. The planning-level cost for new storage at the Otty Road site would be about \$1.8 million. The City should explore cost sharing options with CRW based on current available storage and future needs of both the City and CRW.

Pipeline Improvements. Hydraulic modeling identified the need for approximately \$700,000 in pipeline improvements throughout the City. These improvements are needed to provide water to meet existing peak hour flows in some areas, to provide adequate flows to fight fires in other areas, and to meet the anticipated needs for water from growth and new development. Figure ES-3 illustrates the recommended pipeline improvement projects.

Small Diameter Pipelines. The City's current distribution system includes about 14 miles of 4-inch diameter pipeline or smaller. These pipelines cannot adequately deliver fire flows. The City is already aggressively pursuing a program of abandonment of these small diameter lines. It is recommended that the remaining pipelines be replaced over time as part of an ongoing long-term Capital Maintenance Program with a total replacement cost of approximately \$1.3 million.



Summary

This Master Plan is intended to be a recommended plan and long-term guide for the development of the City's water system. Recommendations in this Master Plan result in a Capital Improvement Program totaling \$2.8 million over the next five years. Total capital needs from the current year (2001/2002) through buildout at 2015 are about \$4.5 million. While projects are listed in this Master Plan as being scheduled for construction in a given year, this is intended only to provide a general guideline of priorities, relationships between projects, and ties to levels of growth. Each year the City should review the Master Plan and adopt a specific Capital Improvement and Capital Maintenance Program which incorporates the general guidelines of the Master Plan into the specific activities for that year. The Master Plan should also be reviewed and updated every five years to account for changing circumstances and new information.

CITY OF MILWAUKIE

**WATER SYSTEM MASTER PLAN
FINAL REPORT**



12/02

January, 2001

MONTGOMERY WATSON

ACKNOWLEDGEMENTS

CITY OF MILWAUKIE

Sue Stepan, Public Works Director
Paul Roeger, Civil Engineer
Jay Saatkamp, Utility Operations Supervisor
Don Simenson, Utility Specialist

PROJECT STAFF

Lisa Obermeyer, Project Manager

Joe Glicker – Technical Advisor
David McPherson – Project Engineer
CJ Hinrichs – Project Engineer

TABLE OF CONTENTS

EXECUTIVE SUMMARY

INTRODUCTION	ES-1
POPULATION FORECAST	ES-2
FIGURE ES-2	ES-3
MILWAUKIE HISTORICAL POPULATION ESTIMATES	ES-3
WATER DEMAND FORECAST	ES-3
PLANNING CRITERIA	ES-6
KEY FINDINGS OF THE SYSTEM EVALUATION	ES-8
SUMMARY	ES-10

SECTION 1 – INTRODUCTION

SCOPE OF WORK	1-2
AUTHORIZATION	1-3

SECTION 2 – POPULATION FORCAST

ESTIMATED RECENT AND CURRENT POPULATION	2-1
EXISTING POPULATION FORECASTS	2-4
WATER SOURCE/DEMAND STUDY	2-4
MILWAUKIE COMPREHENSIVE PLAN	2-4
OTHER POPULATION FORECASTS	2-5

SECTION 3 – WATER DEMAND PROJECTIONS

HISTORICAL WATER DEMANDS	3-2
DISTRIBUTION OF WATER CONSUMPTION BY CUSTOMER CLASS	3-3
UNACCOUNTED-FOR WATER	3-4
WATER DEMAND FORECASTS	3-5
PREVIOUS WATER DEMAND FORECASTS	3-7

SECTION 4 – PLANNING CRITERIA

PLANNING PERIOD	4-1
PLANNING AREA	4-1
DESIGN CRITERIA	4-1

SECTION 5 – EXISTING SYSTEM DESCRIPTION

GENERAL SYSTEM DESCRIPTION	5-1
SUPPLY SYSTEM	5-1
EXISTING SUPPLY FACILITIES	5-6
DISTRIBUTION SYSTEM	5-8
ORGANIZATION AND MANAGEMENT	5-14

SECTION 6 -- EVALUATION OF THE EXISTING SYSTEM

FIELD OBSERVATION OF KEY FACILITIES	6-1
COMPARISON OF KEY FACILITIES TO PLANNING CRITERIA	6-3
HYDRAULIC MODEL EVALUATION	6-15
REVIEW OF OTHER INFORMATION AND ISSUES	6-21

SECTION 7 -- FUTURE SOURCE OF SUPPLY OPTIONS

EVALUATION OF EXISTING SUPPLY	7-1
POTENTIAL SOURCE OPTIONS	7-2
EVALUATION CRITERIA	7-4
EVALUATION RESULTS	7-5
ECONOMIC COMPARISON OF SUPPLY ALTERNATIVES	7-8
ECONOMIC EVALUATION OF THE GROUNDWATER OPTION	7-9
ECONOMIC EVALUATION OF THE CRW OPTION	7-9
ECONOMIC EVALUATION OF THE PORTLAND OPTION	7-10
CONCLUSIONS	7-11
OPTIONS FOR EMERGENCY SUPPLY	7-11

SECTION 8 -- BASIS OF COST ESTIMATES

PIPELINES	8-2
PUMP STATIONS	8-5

SECTION 9 -- SUMMARY OF CAPITAL IMPROVEMENT AND CAPITAL MAINTENANCE RECOMMENDATIONS

PIPELINE CIP	9-1
RESERVOIRS	9-2
PUMP STATIONS	9-2
INTERTIES	9-3
SMALL DIAMETER PIPELINE REPLACEMENT	9-3
OTHER CAPITAL IMPROVEMENT PROJECTS	9-4

EXECUTIVE SUMMARY

Introduction

The City of Milwaukie provides about 5.8 million gallons a day (mgd) of water supply through a system of groundwater wells tapping the Troutdale Aquifer. Since August 1998, the City has supplemented its groundwater supply by purchase of approximately 0.5 mgd of surface water from Clackamas River Water (CRW). The City's water system includes approximately 100 miles of distribution and transmission pipelines, three reservoirs totaling 6.0 million gallons in storage, a pumping station, pressure reducing valves, and other facilities. A schematic of the City's water system is shown in Figure ES-1.

This Master Plan has been prepared to meet the requirements of the Oregon Health Division's (OHD) drinking water regulations and in partial fulfillment of the requirements of Goal 11, Public Facilities and Services, of the State of Oregon land use program. This Goal requires the City "to plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development".

The major elements of the scope of work for this Water System Master Plan were to:

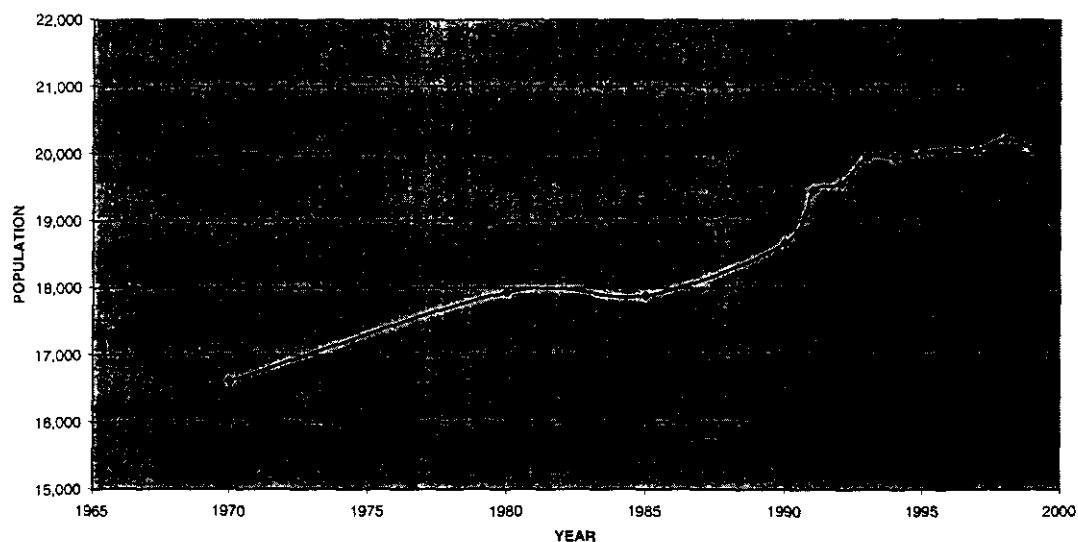
- Review and develop new forecasts of population and water demands,
- Develop planning criteria to be used in evaluating the existing system and future system expansions,
- Evaluate the existing system for deficiencies compared to the planning criteria,
- Develop a source of supply strategy;
- Identify the system improvements needed to support anticipated growth and development and provide means to anticipate system improvements before growth is constrained, and
- Prepare a Capital Improvement Program based on the evaluation of existing and future facilities,

Determining water system rates or financing mechanisms was not a part of the Scope of Work for this Master Plan.

Population Forecast

Water demand forecasts require the estimation of two key parameters - the population that is to be served and the amount of water that population is likely to consume. Population trends over the decades since 1970 are illustrated in Figure ES-2. Population growth slowed significantly in Milwaukie in the early 1980's, in response to the state recession. Growth increased rapidly in the early 1990's and the City has been growing by an average of 0.8 percent per year since that time.

**FIGURE ES-2
MILWAUKIE HISTORICAL POPULATION ESTIMATES**



A number of potential sources and methodologies for forecasting the future population growth for the City are available. These include previous studies, figures from METRO, projections based on historical rates of growth, and the City's own Comprehensive Plan forecast that was adopted in 1999. These estimates are all fairly comparable.

Because the City's Comprehensive Plan forecast incorporates the most rigorous analysis of future development within the City that is currently available, it was used as the basis for population growth for this Master Plan. Based on this forecast, **the assumed total population served at build out will be 27,950 people**. It is also assumed that build out will occur by the year 2015. This number assumes that the City will fully annex Dual Interest Areas A and B, which are unincorporated areas contiguous to the current City boundaries.

Water Demand Forecast

Water demand refers to all the water requirements of a water system including domestic, commercial, municipal, irrigation, institutional and industrial as well as unbilled, unmetered and unaccounted-for water. Demands are discussed in terms of gallons per unit of time such as million gallons per day (mgd). Demands are also related to per capita use in gallons per capita per day (gpcd).

Water demand projections in a Master Plan must be large enough so that the facilities that are being planned will be adequate to cover future water needs in the community. At the same time, the demand forecast must not be too large, as then the planned facilities will also be too large and unnecessarily expensive. The balance between these two concerns must be found. It is important to understand that water demand projections are for planning purposes only. The final sizing and capacity of the recommended facilities should be evaluated and reviewed during individual project predesign to determine their appropriate sizing and other design criteria.

Predicting future water use has several inherent uncertainties. Per capita consumption in a community is influenced by many factors and can vary widely even between adjacent neighborhoods. Table ES-1 illustrates this fact for the City of Milwaukie. It shows historical water production figures for the years 1991 to 1998. Annual, maximum monthly and maximum daily production data and per capita consumption are shown in this Table. These figures include demand exerted by large portions of Area A, even though most of this area has not yet been annexed into the City. Some demand is also being exerted by Area B, although much of this area is currently being served by Clackamas River Water (CRW).

TABLE ES-1
HISTORICAL WATER DEMANDS WITHIN MILWAUKIE CITY LIMITS

YEAR	POPULATION	ANNUAL AVE DEMAND (MGD)	MAX MONTHLY DEMAND (MGD)	MAX DAILY DEMAND (MGD)	RATIO OF MAX TO AVE ANNUAL DEMAND		PER CAPITA DEMAND		
					MAX MONTHLY	MAX DAILY	AVERAGE ANNUAL GPCD	MAX MONTHLY GPCD	MAX DAILY GPCD
1991	19,450	2.65	4.1	5.27	1.5	2.0	136	211	271
1992	19,550	2.68	3.96	5.74	1.5	2.1	137	202	294
1993	19,955	2.56	3.14	4.61	1.2	1.8	128	157	231
1994	19,930	2.67	4.23	5.41	1.6	2.0	134	212	271
1995	20,015	2.59	3.53	4.00	1.4	1.5	129	176	200
1996	20,065	2.75	3.91	4.89	1.4	1.8	137	195	244
1997	20,055	2.54	3.97	4.92	1.6	1.9	127	198	245
1998	20,220	2.47	3.87	5.14	1.6	2.1	122	191	254
1999	20,075	2.52	3.45	4.50	1.4	1.8	126	172	224

note: original data was not provided for years 1991, 1992. Figures taken from 1993 Water Source/Demand Study

As can be seen in Table ES-1, the peak day per capita consumption in Milwaukie varies considerably over this period, from a low of 200 gpcd to a high of almost 300 gpcd. This large a variation in peak demand over an eight year period of record is not uncommon in most communities. For comparison purposes, the peak day per capita consumption over the same period for Oregon City varied from 285 to 381 gpcd, and for the City of West Linn it ranged between 249 to 335 gpcd.

As can be seen by comparing Milwaukie with its neighboring cities, Milwaukie's per capita consumption was at the low end of the range observed in surrounding small cities. This low per capita usage reflects Milwaukie's character as an older, fully developed community. In newer, more rapidly growing communities, residential construction, development and irrigation are major water users. Milwaukie's per capita consumption figure is consistent with an established city, and is more similar to that observed in the City of Portland.

While the peak day per capita consumption can vary significantly from year to year due to the weather, there tends to be an upper limit in a community to the per capita consumption. Based on the distribution of the citywide values, it would not be unreasonable to expect peak day per capita consumption values up to approximately 5% higher than shown in Table ES-1 under extreme weather conditions. Thus, the citywide peak day per capita consumption could reach 300 gpcd in an extremely hot year.

For the purposes of this plan, it is recommended that 280 gpcd be used for peak day consumption for the year 2015 demand projection. This figure is at the high end of historically observed per capita consumption, and provides some system reliability to accommodate hot and dry weather. It also reflects Milwaukie's status as a stable, developed community that will grow mostly by redevelopment and infill over the next 15 years. **It is also recommended that the future average daily per capita demand be assumed to be 140 gpcd.** The peaking factor, defined as the ratio of average to peak daily demand then becomes 2.0, which is a reasonable and commonly used peaking factor, and is consistent with historical records for the City of Milwaukie.

The future water demand forecast is obtained by multiplying the recommended per capita usage rate by the recommended population forecast. The results of this calculation are shown in Table ES-2. It must be recognized that these estimates are predictions based on the best information available at this time, and should be subject to continuous updating and adjustment based on the actual water demand that the City experiences over time.

**TABLE ES-2
CITY OF MILWAUKIE
SUMMARY OF PROJECTED WATER DEMANDS**

YEAR	2015/Buildout
POPULATION	27,950
PEAK DAY PER CAPITA CONSUMPTION (GPCD)	280
AVERAGE DAY PER CAPITA CONSUMPTION (GPCD)	140
AVERAGE DAILY DEMAND (MGD)	3.91
PEAD DAY DEMAND (MGD)	7.83

Planning Criteria

Development of recommendations in this Water System Master Plan depend upon establishment of planning and analysis criteria which are used to evaluate the existing facilities and plan for new facilities. It must be recognized that these planning criteria are not hard and fast rules that must be exactly adhered to in order to provide a reliable water system. They are simply standards by which the system can be judged for the purposes of planning capital improvement and capital maintenance projects under most circumstances. The criteria that have been used in this Master Plan include:

Planning Period. This Water System Master Plan covers a 15-year period to the year 2015. This corresponds to the year of projected ultimate buildout for the City.

Planning Area. The planning area for the Master Plan is the limit of the current City of Milwaukie water system, plus Dual Interest Areas A and B. It is assumed that these areas will be annexed and fully developed by the year 2015, and that the City of Milwaukie will provide water service to these areas.

Service Pressure. The minimum pressure that must be maintained in the system per State of Oregon Health Division standards is 20 pounds per square inch (psi). This pressure

must be maintained even during a fire flow event on a peak demand day. The typical operating pressures that are currently obtained from the existing tanks and reservoirs of between 45 psi and 170 psi should be maintained.

Source. The main source of supply should be capable of providing the projected peak day demand. It should meet this demand with firm capacity - that is, with the largest pump, filter or other component of the system out of service. The City should also have an emergency source of supply that is capable of providing the average day demand for the length of time that the primary source of supply is out of service, such period lasting up to a week. This emergency source could be provided through an intertie, storage, a secondary source, or other methods.

Transmission Pipelines. Transmission pipelines are considered as those greater than or equal to 10-inches in diameter. Pipeline flow velocities in transmission pipelines should be less than 5 feet per second. All water transmission pipelines greater than or equal to 18-inches in diameter should be capable of providing peak day demands. All other transmission pipelines should be capable of supplying peak hour demands.

Distribution Pipelines. Distribution pipelines should be sized to serve peak hour demands and fire flow requirements. Flow velocities for a distribution system pipeline should be below 10 fps and headloss in the pipeline should be below 10 ft per 1000 ft of pipeline. Minimum pipeline diameter for new distribution pipes will be 6-inches in diameter. Any pipeline below 6-inches should be upgraded before being equipped with a fire hydrant. A 6-inch line with a fire hydrant should be part of a looped system or be no more than 500 feet in length.

Pump Stations. Pump stations should be sized for a firm capacity equal to the peak day demand. For reliability, power supplies to pump stations should have either two sources of primary power feed, or one main source and standby or emergency power. The secondary power supply should be sized so that available pumping capacity is equal to average day demand, or fire flow, whichever is greater.

Storage. Storage facilities in water systems are generally provided for four purposes - equalization storage, operational storage, fire storage, and emergency storage. The total storage required in any tank or reservoir is the sum of these four components plus the dead storage (the volume of the tank that is unavailable to use due to physical constraints).

Equalization storage is needed in a water system to meet water system demands in excess of the transmission/pumping delivery capacity from the supply source to the reservoir. A value of 25 percent of peak day demand is recommended for equalization storage. Operational storage may be needed if the supply source does not continuously deliver supply. The City of Milwaukie, however, does not operate its distribution system in a

manner that requires additional operational storage beyond equalization storage, and thus, no additional operational component of storage is recommended in this Master Plan.

Fire storage is provided to meet the single most severe fire flow demand within the system or pressure zone served by the storage facility. The fire storage volume required is determined by multiplying the fire flow rate by the duration of that flow.

Residential fire flows are 1000 gpm for 2 hours and can be applied at any fire hydrant in the pressure zone. Commercial, industrial, and multi-family fire flows can be applied at any fire hydrant within areas that have appropriate land use zoning and may be specific to the zoning and actual facilities in place. A fire flow of 5,000 gpm for 10 hours is a conservative upper limit on storage requirements for zones with commercial, industrial and multi-family uses.

Emergency storage is provided to supply water from storage during emergencies such as power outages, equipment failures, pipelines failures or natural disasters. The amount of emergency storage provided can be highly variable and is dependent upon an assessment of risk and the desired degree of system reliability. An emergency supply equal to one day of average demand within a pressure zone is considered typical for most distribution systems and is appropriate for the City of Milwaukie's system.

It is also desirable, although not required, that storage be provided from at least two separate storage reservoirs or is available through pumping or gravity from a secondary reservoir at a different elevation. This provides for continuous operations during maintenance, repairs or reconstruction or modifications to any single reservoir.

Based on the above criteria, the total recommended required storage in each pressure zone will consist of 25% of projected peak day demand for equalization plus the fire flow demand plus one average day demand for emergencies. This is comparable to the storage requirements set forth in previous studies that the City has conducted.

Key Findings of the System Evaluation

The City's existing water system was evaluated in several ways in this Master Plan. These methodologies were field inspection of key facilities; a comparison of key facilities to the planning criteria; the development of a hydraulic model of the system; and a review of other data, information, and records in the City's files.

The Need for Additional Supply. As indicated in the planning criteria, the water system should be able to meet peak day demand with the largest single component of the supply out of service. The total current capacity of the City's groundwater source is 5.8 mgd and the current capacity of its surface supply from CRW is 0.5 mgd. This provides a total production of 6.3 mgd. The largest component of the supply system is Well No. 7, at 1.4 mgd. If this component is out of service, the resultant firm supply capacity is 4.9 mgd.

This firm capacity is well below the projected peak day demand in 2015 of 7.8 mgd. Using a straight-line projection, projected peak day water demands will outstrip firm capacity by 2002, and will surpass ultimate production capacity by the year 2008. Therefore, it is recommended that 3 mgd of additional firm source capacity be acquired.

The Source of New Supply. The City has two basic alternatives to develop additional supply – to increase its groundwater production by the development of new wells, or to increase its purchase of surface supply from surrounding water providers. In the latter case, potential water providers are the City of Portland, Clackamas River Water (CRW) and the Oak Lodge Water District. The Oak Lodge Water District was eliminated from consideration after preliminary discussions with them indicated that it is not an option for the time period of this Master Plan. The remaining three alternatives were evaluated in more detail. The evaluation considered qualitative criteria and relative comparisons of costs. The qualitative criteria that were considered were:

- Certainty of Supply.
- Water Quality.
- Reliability.
- Ease of Implementation.
- Consistency with local and regional planning.
- Compatibility with existing facilities.
- Ownership and Agreements.

Cost considered capital, operating and maintenance costs.

The CRW and groundwater options were similar in cost, at about \$3.4 million over the life of the Master Plan. The City of Portland option was \$5.2 over the same period. The qualitative evaluation favored the CRW option. It ranked high on all the qualitative criteria and its use diversifies the City's sources and strengthens its emergency interconnections.

Water conservation was considered in this Master Plan as a method of delaying the need for additional water supply. It is important to note that current water demands in the City of Milwaukie already reflect conservation which has occurred in the region since the 1992 drought. The Portland Water Bureau estimates that a reduction in demand of 10 to 15 percent has occurred throughout the region in response to actions taken by water providers in 1992 and subsequent years. Milwaukie experienced a high per capita demand in the drought year of 1992 of 294 gpcd. Although there was a small spike upward in 1994 (another drought year), per capita consumption has so far not climbed back up to 1992 levels. In 1998/1999, per capita consumption was still 85 percent of the 1992 consumption rate. This suggests that conservation messages and practices continue to have an effect on consumption. By 2015, peak day demand is projected to reach 7.3 million gallons per day. This is a 50 percent increase over 1998/1999 peak day demands, and will be fueled by population growth. Water conservation cannot replace the need for

additional supply at these levels, but it may be able to affect the timing of necessary improvements. Conservation is therefore an important element of the City's overall water supply strategy.

To further strengthen emergency water supply, it is recommended that the City develop emergency interties and emergency supply agreements with its other neighboring water providers, the City of Portland and the Oak Lodge Water District. The City of Portland intertie is already under development. A previous intertie with the Oak Lodge Water District that is now inoperable should be reactivated.

New Storage. The City currently maintains 6 million gallons (MG) of storage in three reservoirs. Based upon the planning criteria for storage, the City needs an additional 1.5 MG of storage to serve its current population. This storage deficit will grow to 2.5 MG at buildout. Ideally, storage for each pressure zone would be provided from a reservoir that feeds that zone via gravity. However, the topography and location of reservoir sites in the City of Milwaukie has required that much of the City's existing storage be provided through pumping from lower elevations.

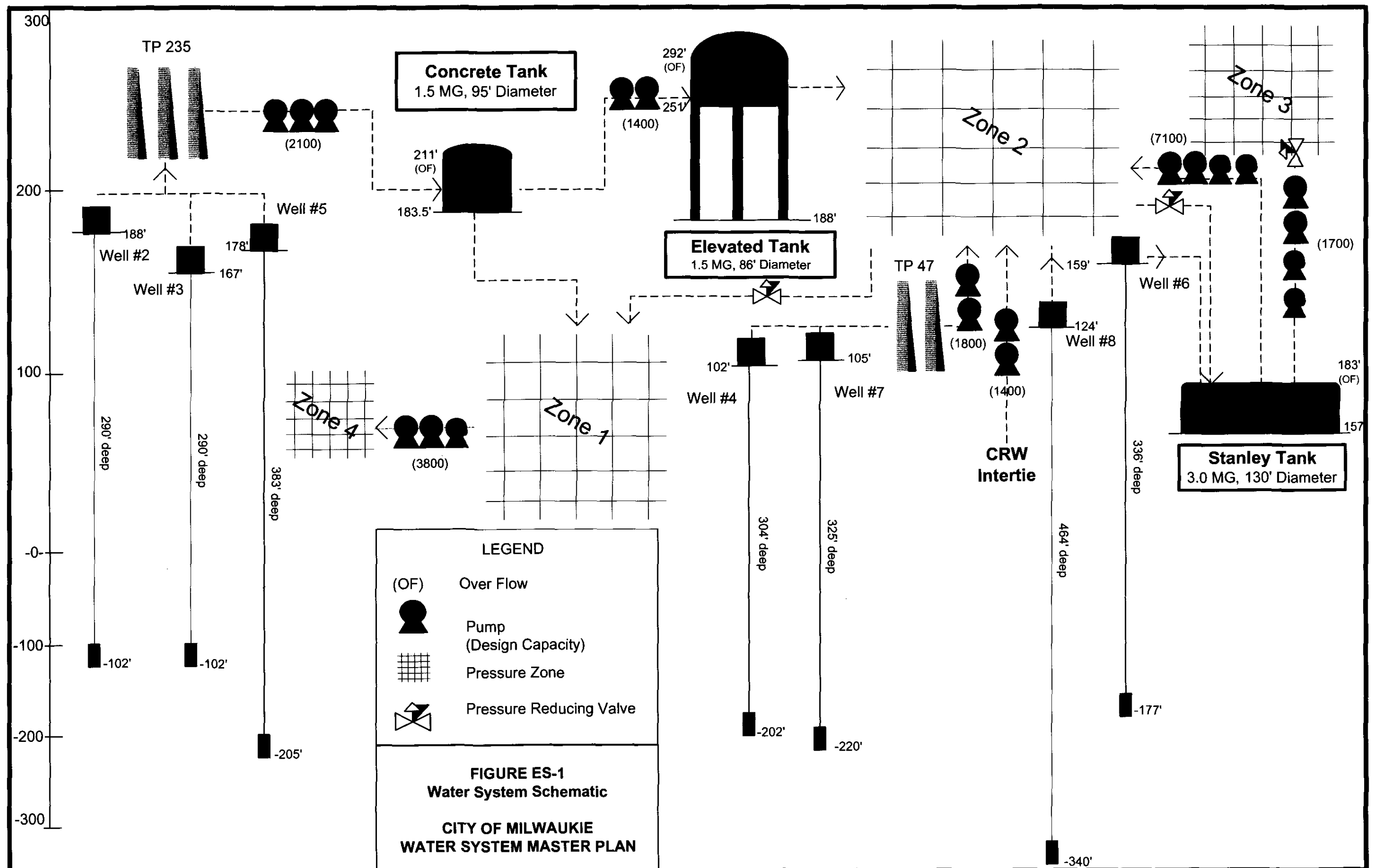
Several options for new storage were investigated in this Master Plan. The most economically favorable option to the City is joint storage with CRW at the site of their existing Otty Road Reservoir complex. CRW currently has excess storage capacity available at that site and can build more storage over time to accommodate growth for Milwaukie and CRW. Water stored at that site is of an elevation that allows for its use by gravity. Use of this site for storage also integrates with the recommendation for a new source of supply from CRW at this location. The Master Plan recommends pursuing joint storage with CRW. The planning-level cost for new storage at the Otty Road site would be about \$1.8 million. The City should explore cost sharing options with CRW based on current available storage and future needs of both the City and CRW.

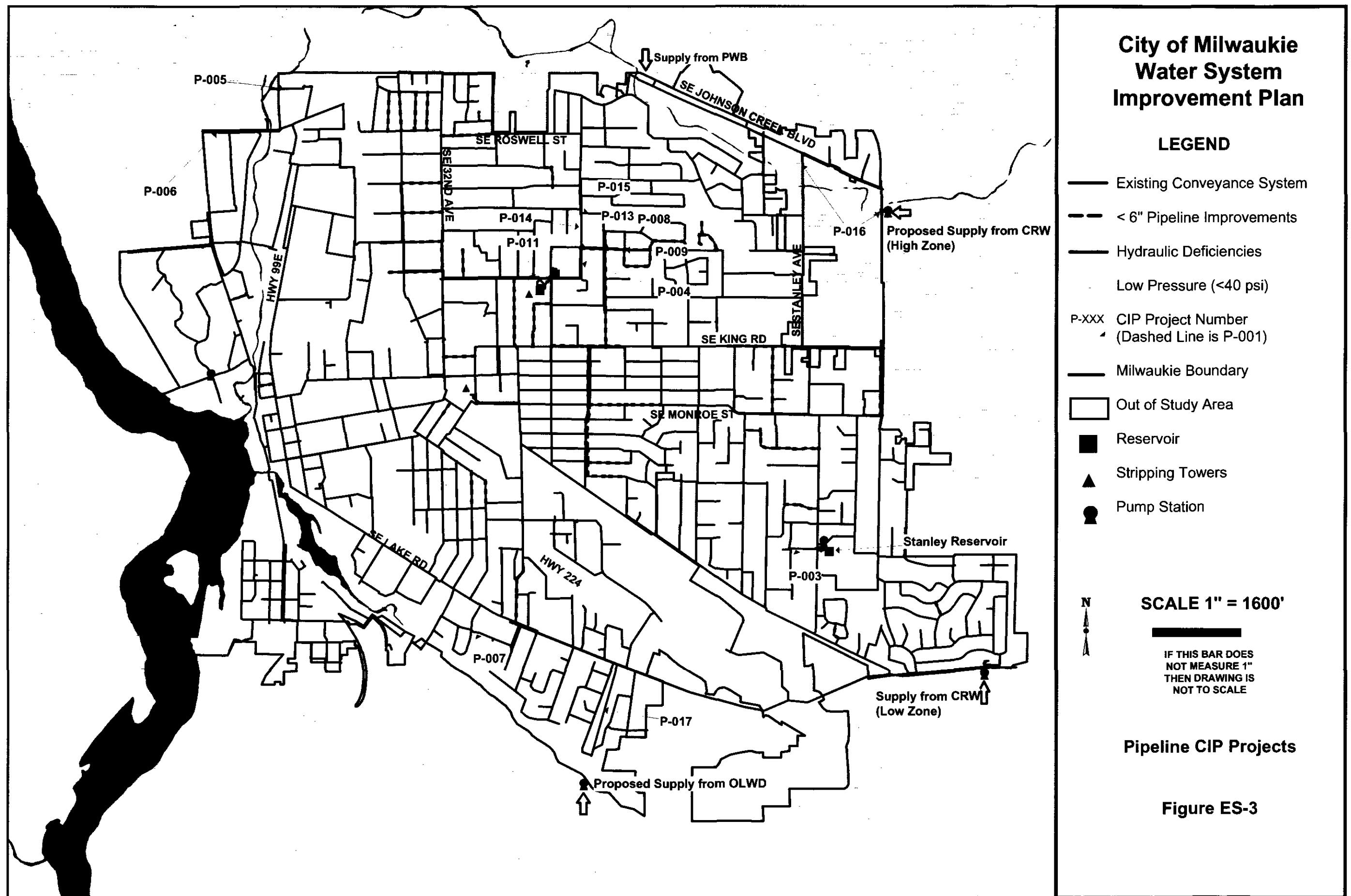
Pipeline Improvements. Hydraulic modeling identified the need for approximately \$700,000 in pipeline improvements throughout the City. These improvements are needed to provide water to meet existing peak hour flows in some areas, to provide adequate flows to fight fires in other areas, and to meet the anticipated needs for water from growth and new development. Figure ES-3 illustrates the recommended pipeline improvement projects.

Small Diameter Pipelines. The City's current distribution system includes about 14 miles of 4-inch diameter pipeline or smaller. These pipelines cannot adequately deliver fire flows. The City is already aggressively pursuing a program of abandonment of these small diameter lines. It is recommended that the remaining pipelines be replaced over time as part of an ongoing long-term Capital Maintenance Program with a total replacement cost of approximately \$1.3 million.

Summary

This Master Plan is intended to be a recommended plan and long-term guide for the development of the City's water system. Recommendations in this Master Plan result in a Capital Improvement Program totaling \$2.8 million over the next five years. Total capital needs from the current year (2001/2002) through buildout at 2015 are about \$4.5 million. While projects are listed in this Master Plan as being scheduled for construction in a given year, this is intended only to provide a general guideline of priorities, relationships between projects, and ties to levels of growth. Each year the City should review the Master Plan and adopt a specific Capital Improvement and Capital Maintenance Program which incorporates the general guidelines of the Master Plan into the specific activities for that year. The Master Plan should also be reviewed and updated every five years to account for changing circumstances and new information.





SECTION 1—INTRODUCTION

The City of Milwaukie provides water supply through a system of groundwater wells tapping the Troutdale Aquifer. The City currently supplements its groundwater supply by purchase of surface water from Clackamas River Water (CRW). Total groundwater production capacity is about 5.8 mgd, with individual wells ranging in capacity from 400 to 1,000 gallons per minute (gpm). The City maintains two air-stripping facilities for the removal of low levels of volatile organic chemicals from the groundwater. Approximately 0.5 million gallons per day (mgd) of surface water has been purchased from CRW since August of 1998.

The City of Milwaukie's water system includes:

- a system of seven operational groundwater wells scattered throughout the City, with two central treatment facilities;
- approximately 100 miles of distribution and transmission pipelines,
- three reservoirs totaling 6.0 million gallons in storage, groundwater pumps, a pumping station, pressure reducing valves, and other facilities.

The City also maintains an emergency intertie with the City of Portland.

The City completed two studies in the 1990's that evaluated water system demands and examined potential future supply options. These studies were heavily focused on future water supply options. The 1993 Water Source/Demand Study (Cunningham Associates, Inc.) recommended the development of additional groundwater supply. Interim supply from City of Portland, Oak Lodge Water District or Clackamas River Water was also recommended, requiring the construction of connections capable of supplying peak day and emergency needs. An additional 2.3 million gallons of storage was recommended to meet demand to 2015. In the event that the City's groundwater supply were to be abandoned due to contamination, it was recommended that Milwaukie join the Oak Lodge Water District and participate in the construction of the slow sand filter plant. This plant came on line in the summer of 1999. The 1993 Study also recommended that the City of Milwaukie prepare and adopt a comprehensive water system master plan.

A follow up supply study was prepared for the City in 1996 (Water Source/Demand Study Update, Murray Smith and Associates, 1996). This study assumed that the City would continue to rely on groundwater as its primary supply, but would need to develop supplemental sources to meet growth. This study recommended contracting with CRW for purchase of a base water supply. City wells would continue to be used to supply demands above the base amount. Estimated capital costs for a connection to CRW were estimated to be \$134,000. The total estimated cost of water supply for a 20-year period was estimated to be \$11,833,000.

This Master Plan fulfills the recommendation of the 1993 Study, and is also prepared in partial fulfillment of the requirements of Goal 11, Public Facilities and Services, of the State of Oregon land use program. This Goal requires the City "to plan and develop a timely,

orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development”.

This Master Plan is intended to be a recommended plan and long-term guide for the development of the City’s water system. It is not intended to be a specific list of required projects for specific years. While projects are listed in this Master Plan as being scheduled for construction in a given year, this is intended only to provide a general guideline of priorities, relationships between projects, ties to levels of growth, and understanding of maintenance priorities. Each year the City should review the Master Plan and adopt a specific Capital Improvement and Capital Maintenance Program which incorporates the general guidelines of the Master Plan into the specific activities for that year. The Master Plan should also be reviewed and updated every five years to account for changing circumstances and new information.

Scope of Work

The general scope of work for this project was to prepare a Water System Master Plan. The scope included tasks to:

- Review and develop new forecasts of population and water demands,
- Develop planning criteria to be used in evaluating the existing system and future system expansions,
- Evaluate the existing system for deficiencies compared to the planning criteria,
- Develop a source of supply strategy;
- Identify the system improvements needed to support anticipated growth and development and provide means to anticipate system improvements before growth is constrained,
- Prepare a Capital Improvement Program based on the evaluation of existing and future facilities,

Determining water system rates or financing mechanisms was not a part of the Scope of Work for this Master Plan.

Authorization

Montgomery Watson was selected to prepare this Master Plan by the City in response to a Request for Proposals from the City of Milwaukie dated January 29, 1999. A contract authorizing the work was signed and dated August 13, 1999.

SECTION 2 – POPULATION FORECAST

Water demand forecasts require the estimation of two key parameters - the population that is to be served and the amount of water each member of that population is likely to consume. This Section provides the estimate for population that will be used in the Milwaukie Water Master Plan. Section 3 presents water demand projections based on these population forecasts.

Population projections given in this Section assume that ultimate buildout for the City will be reached by 2015. This assumption is based on discussions with City staff, and their understanding of Milwaukie's current and anticipated growth patterns.

Estimated Recent and Current Population

Recent historical population estimates for the City of Milwaukie were obtained from the Center for Population Research and Census, Portland State University (PSU), for the years 1990 to 1998. The PSU data represents estimates of population on July 1 each year within the Milwaukie City limits. Their estimates are based on census counts published by the U.S. Census Bureau every ten years. Annual estimates between census counts are derived by analyzing supplemental data, including economic changes, building permits, vehicle registrations, annexations, and other data.

These recent estimates have been combined with historical actual population figures provided by the City of Milwaukie's Comprehensive Plan, most recently revised in 1999. Population trends over the decades since 1970 are presented in Table 2-1 and are illustrated in Figure 2-1. Population growth slowed significantly in Milwaukie in the early 1980's, in response to the state recession. Growth increased rapidly in the early 1990's and the City has been growing by an average of one percent per year since that time.

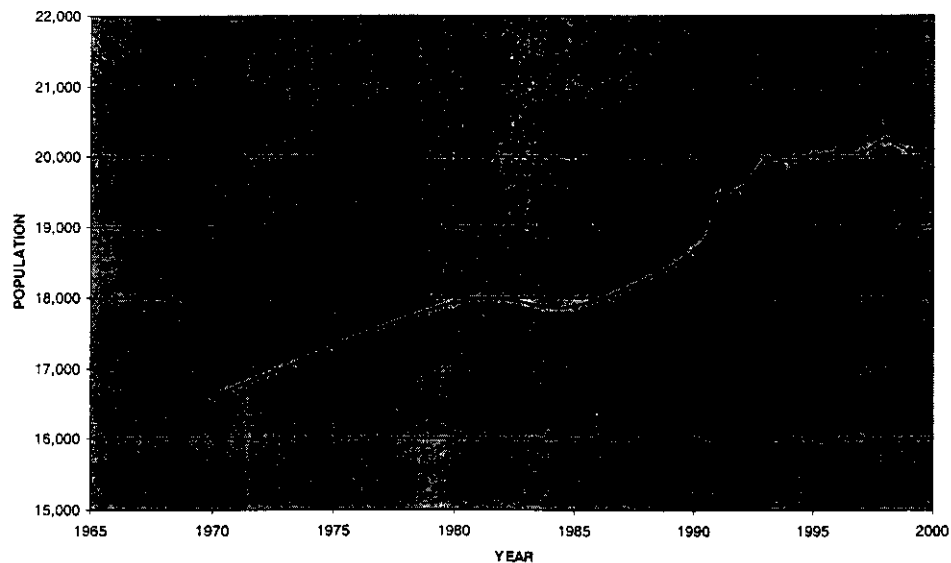
TABLE 2-1
CITY OF MILWAUKIE
HISTORICAL POPULATION ESTIMATES

YEAR	POPULATION	% ANNUAL GROWTH	AVE 10-YEAR GROWTH
1970	16,609		
1980	17,931	0.80	0.8
1985	17,884	-0.05	
1990	18,670	0.88	0.4
1991	19,450	4.18	
1992	19,550	0.51	
1993	19,955	2.07	
1994	19,930	-0.13	
1995	20,015	0.43	
1996	20,065	0.25	
1997	20,055	-0.05	
1998	20,220	0.82	
1999	20,075	-0.7	0.8

* PSU data from 1990-1999

* figures for 1970, 1980, 1985 from Milwaukie Comp Plan

FIGURE 2-1
MILWAUKIE HISTORICAL POPULATION ESTIMATES



Existing Population Forecasts

Water Source/Demand Study

The Water Source/Demand Study (Cunningham Associates, 1993) provides population projections based on regional forecasts prepared by Metro in 1989. The Metro forecasts utilize the inventory of developable lands within the City limits to predict ultimate population for the City. Population at buildout is estimated to be 23,847 within the current City limits.

The 1993 Study also estimates the impact of population growth in two major unincorporated areas contiguous to the City's boundary. These unincorporated areas have been designated in previous plans as "Area A" and "Area B". The location of these areas is shown in Figure 2-2. These areas have been designated by the City and by Clackamas County as "Dual Interest Areas". The City will lead in providing urban services to these areas. Thus, they must be considered in the development of population and water demand projections.

Metro estimated the buildout population of Areas A and B based on aerial surveys of undeveloped land in 1990, zoning designations and assumptions of density for different types of dwelling units. According to these estimates, an additional 2,750 persons must be served at buildout assuming full annexation of these areas, bringing the total service population at buildout to **26,597**.

Milwaukie Comprehensive Plan

The Comprehensive Plan has estimated a population for the year 2005 of 20,300. This figure is based on projections supplied by Metro in 1987. This projection results in a very low growth rate, about 0.05 percent per year, between 1998 and 2005.

City staff have also estimated the number of new dwelling units that will result from full development of vacant buildable lands within the City (revised April 1999). As described in the Comprehensive Plan, at the time of full development a total of 2,827 new dwelling units will be added to the City's housing stock. The Regional Center is expected to accommodate about 63 percent of these new units through infill and redevelopment, while vacant land outside the Regional Center will absorb the remainder of the new units.

Based on the City's estimate of new dwelling units in each residential zone, a total of about 2,391 persons will be added to the City's population through full development of vacant lands outside the Regional Center. Another 2,586 people will be added by redevelopment of higher density, multifamily units inside the Regional Center. The total population at buildout within the City boundaries is thus projected to be 25,199.

Considering the previously described Metro projections for development in Areas A and B, an additional 2,750 people will exert demand for water in these areas at buildout. Thus the total buildout population for the City and contiguous areas is **27,950**. This number is about

five percent higher than the projection given by the Metro aerial lands survey conducted in 1990.

Other Population Forecasts

Rate of Growth Projection

Another method of population forecasting for the City is to assume that future growth will be similar to past growth. Between 1990 and 1999, the population served by the City's water system grew from 18,670 to 20,075, for an average of 156 persons per year, or about 0.8 percent growth per year. If that same average were to continue to the year 2015 (the assumed buildout for the Water Master Plan) then the 2015 population would be about 22,804. Combined with projections for development in Areas A and B, the total buildout population for the City and contiguous areas becomes 25,554. This about four percent lower than the estimate provided by Metro in the 1993 Water Source/Demand Study.

Recommended Population Forecast

The results of the various population forecasts are summarized in Table 2- 2. The three estimates given by the 1993 Source/Demand Study, the Milwaukie Comprehensive Plan and the Rate of Growth projection are fairly comparable, varying within ten percent of each other. Population projections are illustrated graphically in Figure 2-3.

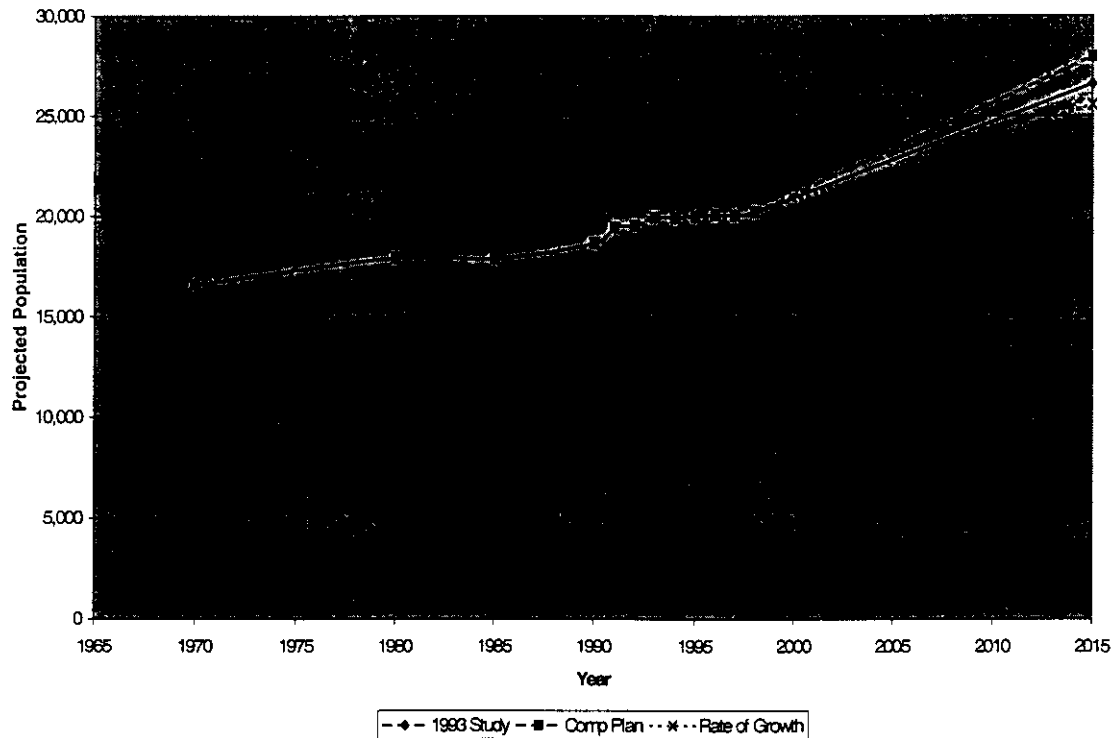
It is recommended that a total population of 27,950 be considered as the build out projection for the purposes of this Water System Master Plan. This estimate is based on a detailed residential development analysis conducted by the City in 1998, and incorporates the most rigorous analysis of future development within the City that is available at this time. This estimate, based on the City's Comprehensive Plan, is consistent with historically observed low growth rates in Milwaukie in the 1990's. This estimate is also consistent with previous Metro projections, although it is slightly more conservative in terms of water supply planning in that it gives higher population and therefore higher projected water demands.

It should be noted that this estimate is a prediction based on the best information available at this time, and should be subject to continuous updating and adjustment based on the actual population growth that the City experiences over time. This number assumes that buildout will be achieved by the year 2015, based on the limited stock of available land within the City, and the observed growth rates in the Portland area. This number also assumes that the City will fully annex Dual Interest Areas A and B by the year 2015, and will provide water service to these areas.

**TABLE 2-2
CITY OF MILWAUKIE
SUMMARY OF POPULATION FORECASTS
AT 2015/BUILDOUT**

SOURCE	City	City Plus Areas A&B
1993 Source/Demand Study	23,850	26,600
Comprehensive Plan	25,200	27,950
Historic Rate of Growth	22,804	25,554

**Figure 2-3
Summary of Population Projections**



SECTION 3 – WATER DEMAND PROJECTIONS

In Section 2, population forecasts for the City of Milwaukie to the year 2015 were presented, corresponding to the assumed year of ultimate buildout for the City. In this Section, those population projections are utilized along with historical water demand information for Milwaukie to forecast future water demands. These demand forecasts will be utilized in the facilities planning for the Water System Master Plan.

The term “demand” refers to all the water requirements of a water system including domestic, commercial, municipal, irrigation, institutional and industrial as well as unbilled, unmetered and unaccounted-for water. Demands are discussed in terms of gallons per unit of time such as gallons per day (gpd), million gallons per day (mgd) or gallons per minute (gpm). Demands are also related to per capita use as gallons per capita per day (gpcd).

The level of effort and sophistication that goes into estimating water demands can vary substantially. The demand projections in this Section rely upon historical information from the City and engineering judgment. In making a projection, it is important to understand the use of that projection. For this Water System Master Plan, the demand projections must be large enough so that the facilities that are planned will be adequate to cover future water needs in the community. At the same time, the demand forecast must not be too large, as then the planned facilities will also be too large and unnecessarily expensive. The balance between these two concerns must be found. It is also important to understand that these projections are for planning purposes only. The final sizing and capacity of the recommended facilities should be evaluated against growth trigger points and reviewed during individual project predesign to determine their appropriate sizing and other design criteria.

Historical Water Demands

Table 3-1 shows historical water production figures for the years 1991 to 1999. Annual, maximum monthly and maximum daily production data are shown in this Table. The population values in this Table are from the Center for Population Research and Census at Portland State University for the city limits of Milwaukie as listed in Table 2-1. Per capita demands are calculated by taking the production numbers and dividing by the corresponding populations. These per capita usage rates include all residential, commercial, municipal, industrial and institutional uses, as well as unaccounted-for water. The per capita consumption figures are calculated as a citywide average. There may be significant variation in per capita consumption within areas of the City depending on nature of the development present, the amount of new development compared to established development, and other factors. These figures include demand exerted by large portions of Area A, even though most of this area has not yet been annexed into the City. Some demand is also being exerted by Area B, although much of this area is currently being served by Clackamas River Water (CRW).

**TABLE 3-1
HISTORICAL WATER DEMANDS WITHIN MILWAUKIE CITY LIMITS**

YEAR	POPULATION	ANNUAL AVE DEMAND MGD	MAX MONTHLY DEMAND MGD	MAX DAILY DEMAND MGD	RATIO OF MAX TO AVE ANNUAL DEMAND		PER-CAPITA DEMAND		
					MAX MONTHLY	MAX DAILY	AVERAGE ANNUAL GPCD	MAX MONTHLY GPCD	MAX DAILY GPCD
1991	19,450	2.65	4.1	5.27	1.55	1.99	136	211	271
1992	19,550	2.68	3.96	5.74	1.48	2.14	137	202	294
1993	19,955	2.56	3.14	4.61	1.23	1.80	128	157	231
1994	19,930	2.67	4.23	5.41	1.58	2.03	134	212	271
1995	20,015	2.59	3.53	4.00	1.36	1.54	129	176	200
1996	20,065	2.75	3.91	4.89	1.42	1.78	137	195	244
1997	20,055	2.54	3.97	4.92	1.56	1.94	127	198	245
1998	20,220	2.47	3.87	5.14	1.57	2.08	122	191	254
1999	20,075	2.52	3.45	4.50	1.40	1.80	126	172	224

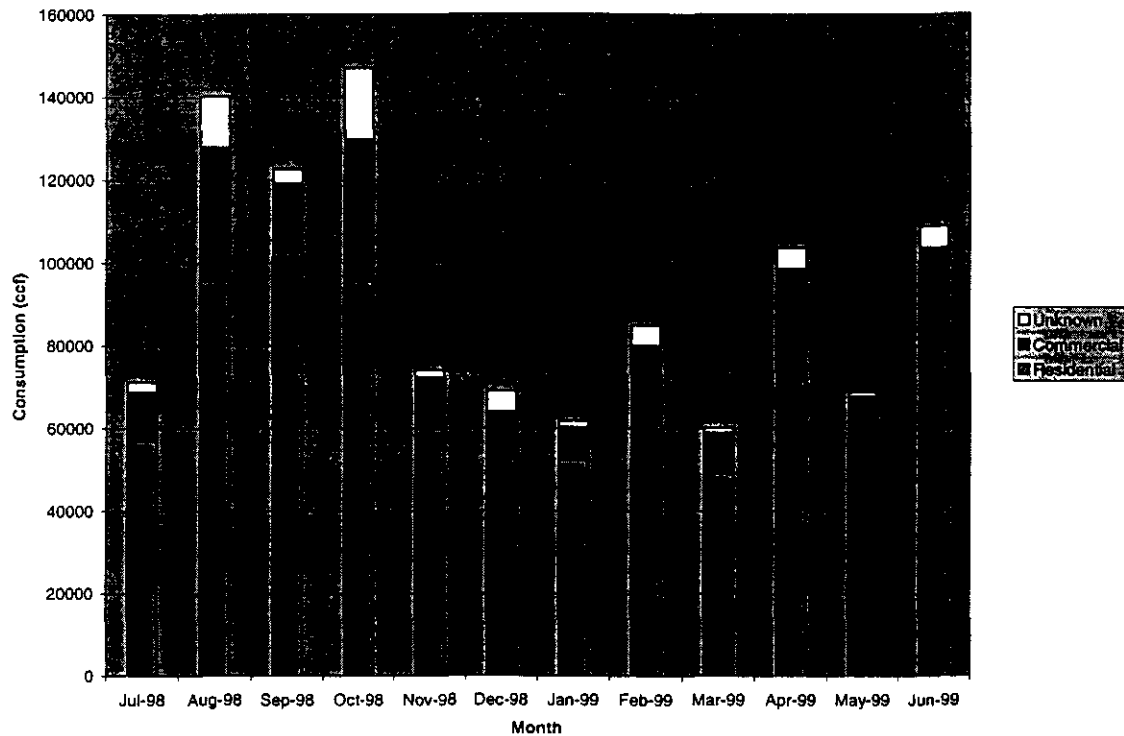
note: original data was not provided for years 1991, 1992. Figures taken from 1993 Water Source/Demand Study

As can be seen in Table 3-1, the peak day per capita consumption in Milwaukie varies considerably over this period, from a low of 200 gpcd to a high of almost 300 gpcd. For comparison purposes, the peak day per capita consumption over the same period for Oregon City varied from 285 to 381 gpcd, and for the City of West Linn it ranged between 249 to 335 gpcd. For 1994, the per capita consumption in the South service area of Clackamas River Water was 342 gpcd. While a variation of 100 gpcd over the eight year period of record is common, as can be seen by comparing Milwaukie with neighboring cities, Milwaukie's per capita consumption was at the low end of the range observed in surrounding small cities. No year in the last decade has seen a per capita consumption above 300 gpcd. This low per capita usage reflects Milwaukie's character as an older, fully developed community. In newer, growing communities, residential construction, development and irrigation are major water users. Milwaukie's per capita consumption figure is consistent with an established city, and is more similar to that observed in the City of Portland.

Distribution of Water Consumption by Customer Class

City staff prepared estimates of water consumption by customer class for the most recent fiscal year, from July 1998 to June 1999. Water consumption in Milwaukie is primarily residential, averaging about 80 percent residential to 20 percent commercial consumption in 1998/1999. Figure 3-1 illustrates the monthly distribution of consumption between residential and commercial accounts. The relative fraction of residential versus commercial use appears to have remained stable over the last decade. The 1993 Water Demand/Supply Study indicated 81 percent residential use and 19 percent commercial use for the year 1991.

**FIGURE 3-1
CONSUMPTION DISTRIBUTION**



Unaccounted-for Water

Unaccounted-for water is measured as the difference between water produced and water sold. Water loss is typically attributed to unmetered water delivery, inaccurate metering equipment or system leaks. Acceptable water losses industry-wide are considered to be less than 15 percent.

Monthly billing and production records were compared for the most recent fiscal year from July 1998 to June 1999. The percent difference between water delivered to the system and water consumed over this 12 month period was very low, about 5 percent. The City's own internal estimates of unaccounted-for water indicate losses averaging about 10 percent per year.

Milwaukie has reduced its unaccounted for water over the last decade through a program of meter replacement, water main replacement and leak repair. Out of a total of 6,500 residential meters, about 6,000 of these have been replaced in the last five years. Milwaukie has also opted to contract its meter reading to a private service, Meter Readers, Inc. of Lake Oswego. The City has estimated that use of the service has reduced meter-reading errors and has resulted in labor cost savings. Annual cost of the meter reading service is about \$15,000. The City also maintains an aggressive program of water main replacement, and annually budgets \$300,000 to \$400,000 for replacement of aging water mains. The observed

incidence of leaks has declined over the past several years, according to City staff estimates. These efforts appear to be paying off in terms of reducing water loss. Current water losses probably range between five and ten percent. The 1993 Water Demand/Supply Study indicated an unaccounted for water figure of 15 percent for the year 1991.

Water Demand Forecasts

Per Capita Consumption

The water demand forecasts that are developed in this study will be used in planning for future upgrades and expansions of the City of Milwaukie's water supply system. If the water demand forecasts are too far above the actual future water demand, then there is a danger that the facilities that are planned for the future will be larger and more expensive than needed. If the demand projections are too far below the actual future water demand, then there is the danger that the facilities that are planned for the future will be inadequate.

Predicting future water use has several inherent uncertainties. Per capita consumption in a community is influenced by many factors and can vary widely even between adjacent neighborhoods. Among the factors which cause this variability are the relative mix between residential, commercial and industrial users; the amount and type of landscaping; the area of lots which are irrigated; the use of automatic irrigation systems; the kind of irrigation systems that are used; the age of plumbing facilities in homes; the size of families in the neighborhood; and the amount of multifamily housing compared to single family housing. In addition, the peak demand in any given year is greatly influenced by the weather. The amount and frequency of summer rains and the temperature and duration of summer hot spells will vary substantially from year to year. Thus, the per capita consumption in any community can vary significantly from year to year as shown in Table 3-1.

Possible future changes in per capita consumption can occur due to conservation programs, the reduction (or increase) in unaccounted-for water, and changes in the mix of residential, industrial, and commercial water use. This latter change can occur if a large manufacturing facility were to locate in or leave the City. The water demand characteristics of future residential growth also may not replicate the water demand characteristics of historical residential use, due to differences in lot sizes, landscaping, and the number and nature of water using fixtures. Denser development tends to have lower per capita consumption than more spread out development. New neighborhoods tend to have higher per capita consumption than more established neighborhoods due to construction activity, new lawns, and a greater prevalence of automatic sprinkling systems.

As shown in Table 3-1, the recent historical average daily per capita demand ranged from approximately 122 gpcd in 1998 to approximately 137 gpcd in 1992 and 1996, a variation of about 12 percent. The average per capita demand over this period was 131 gpcd. As can be also be seen from this Table, the estimated peak day per capita consumption for the City as a whole varied from a low of 200 gpcd in 1995 to a high of 294 gpcd in 1992, a variation of about 50 percent. Three of the eight years shown in this Table have a City-wide peak day

consumption between 244 and 254 gpcd, with two years being below this range and three years being above this range.

While the peak day per capita consumption can vary significantly from year to year due to the weather, there tends to be an upper limit in a community to the per capita consumption. Based on the distribution of the citywide values, it would not be unreasonable to expect peak day per capita consumption values up to approximately 5% higher than shown in this Table 3-1 under extreme weather conditions. Thus, the citywide peak day per capita consumption could reach 300 gpcd in an extremely hot year.

Recommended Per Capita Consumption

The decision as to which peak day per capita consumption value to use relates to the desired level of system reliability. There is often a relationship between the level of reliability and cost - higher levels of reliability result in higher costs. The reliability of local distribution system components, such as transmission and distribution pipelines and local pump stations and tanks, tend to be designed toward the upper end of a reliability range. Using a higher level for peak day per capita consumption provides a higher degree of certainty that even in the most extreme weather conditions, adequate water will be available. This higher consumption value will result in more costly facilities, however. Other methods of dealing with extreme peaks in demand include reliance on temporary curtailment of water use or interties to other sources.

For the purposes of this plan, it is recommended that 280 gpcd be used for peak day consumption for the year 2015 demand projection. This figure is at the high end of historically observed per capita consumption, and provides some system reliability to accommodate hot and dry weather. It also reflects Milwaukie's status as a stable, developed community that will grow mostly by redevelopment and infill over the next 15 years.

For the purposes of this plan, it is also recommended that the future average daily per capita demand be assumed to be 140 gpcd. This is slightly more conservative than the arithmetic average of the average daily per capita demand of 131 gpcd, observed over the eight-year period of 1991 through 1998. The peaking factor, defined as the ratio of average to peak daily demand then becomes 2.0, which is a reasonable and commonly used peaking factor.

It must be recognized that these estimates are predictions based on the best information available at this time, and should be subject to continuous updating and adjustment based on the actual water demand that the City experiences over time.

Projected Water Demand

The future water demand forecast is obtained by multiplying the recommended per capita usage rate discussed above by the recommended population forecast from Section 2. The results of this calculation are shown in Table 3-2. This estimate includes Areas A and B, and assumes that these areas will be fully developed by 2015 and that the City of Milwaukie will provide water service to these areas.

**TABLE 3-2
CITY OF MILWAUKIE
SUMMARY OF PROJECTED WATER DEMANDS**

YEAR	2015/Buildout
POPULATION	27,950
PEAK DAY PER CAPITA CONSUMPTION (GPCD)	280
AVERAGE DAY PER CAPITA CONSUMPTION (GPCD)	140
AVERAGE DAILY DEMAND (MGD)	3.91
PEAK DAY DEMAND (MGD)	7.83

Previous Water Demand Forecasts

The 1993 Water Source/Demand Study presented demand forecasts at buildout for the City of Milwaukie. This study predicted an average day water demand of 3.64 mgd, including full development of areas A and B. This is slightly lower than the current recommended projection of 3.91 mgd. There are two reasons for the difference in projections. The 1993 Study projected a buildout population about five percent lower than the one recommended for this Master Plan. The current projection is based on the City's Comprehensive Plan evaluation of remaining buildable lands, conducted in 1998. The 1993 Study also used a slightly lower per capita figure of 137 gpcd, versus the 140 gpcd recommended for this Master Plan.

The 1993 Study projected a peak day demand of 8.75 mgd at buildout. This is higher than the 7.83 mgd recommended in this Master Plan. The 1993 Study applied a peaking factor of 2.4 to calculate peak day demand based on average day demands. As discussed above, this factor is unnecessarily conservative. Recent years have seen more emphasis in conservation and wise water use. The Portland region has experienced success with trimming the summertime peaking factor through public education campaigns. These efforts were undertaken in response to the drought years, particularly the summer of 1994. The City of Milwaukie showed a 25 percent drop in per capita water demand in 1995, presumably in

response to intensive conservation messages. These conservation messages are still effective. While per capita consumption has been climbing since 1995, it has not reached pre-drought levels.

The 2.0 peaking factor recommended in this Master Plan is more appropriate for a mature community, while still providing system reliability in peak use periods. This factor is more consistent with the current emphasis on conservation and water-efficient fixtures. This factor will remain appropriate, as Milwaukie continues to develop at higher density in the Regional Center. Higher-density development typically uses less water per capita because of lower landscaping requirements. New development also reduces per capita consumption as more water-efficient fixtures are installed.

The Regional Water Supply Plan (RWSP) developed long range water demand forecasts for water providers in the Portland Metro area, to the year 2050. These forecasts were developed in the early 1990's based on predicted land use and growth patterns. The RWSP forecast for Milwaukie is overly conservative, predicting a 1998 peak day demand of 8.9 mgd, compared to an actual peak day use of 5.14 mgd in that year. The RWSP predicted peak day use for 2015 is 9.34. This is about 1.5 mgd higher than the recommended figure of 7.83 mgd. The RWSP projections flatten out over time as the projected growth curve for the region flattens out, so that the RWSP numbers may become more accurate over time.

SECTION 2 – POPULATION FORECAST

Water demand forecasts require the estimation of two key parameters - the population that is to be served and the amount of water each member of that population is likely to consume. This Section provides the estimate for population that will be used in the Milwaukie Water Master Plan. Section 3 presents water demand projections based on these population forecasts.

Population projections given in this Section assume that ultimate buildout for the City will be reached by 2015. This assumption is based on discussions with City staff, and their understanding of Milwaukie's current and anticipated growth patterns.

Estimated Recent and Current Population

Recent historical population estimates for the City of Milwaukie were obtained from the Center for Population Research and Census, Portland State University (PSU), for the years 1990 to 1998. The PSU data represents estimates of population on July 1 each year within the Milwaukie City limits. Their estimates are based on census counts published by the U.S. Census Bureau every ten years. Annual estimates between census counts are derived by analyzing supplemental data, including economic changes, building permits, vehicle registrations, annexations, and other data.

These recent estimates have been combined with historical actual population figures provided by the City of Milwaukie's Comprehensive Plan, most recently revised in 1999. Population trends over the decades since 1970 are presented in Table 2-1 and are illustrated in Figure 2-1. Population growth slowed significantly in Milwaukie in the early 1980's, in response to the state recession. Growth increased rapidly in the early 1990's and the City has been growing by an average of one percent per year since that time.

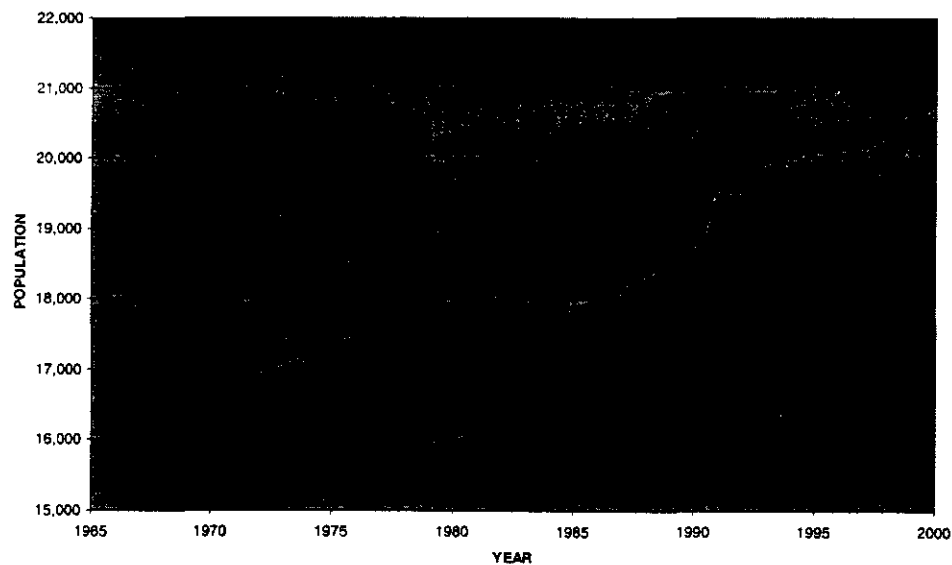
**TABLE 2-1
CITY OF MILWAUKIE
HISTORICAL POPULATION ESTIMATES**

YEAR	POPULATION	% ANNUAL GROWTH	AVE 10-YEAR GROWTH
1970	16,609		
1980	17,931	0.80	0.8
1985	17,884	-0.05	
1990	18,670	0.88	0.4
1991	19,450	4.18	
1992	19,550	0.51	
1993	19,955	2.07	
1994	19,930	-0.13	
1995	20,015	0.43	
1996	20,065	0.25	
1997	20,055	-0.05	
1998	20,220	0.82	
1999	20,075	-0.7	0.8

* PSU data from 1990-1999

* figures for 1970, 1980, 1985 from Milwaukie Comp Plan

**FIGURE 2-1
MILWAUKIE HISTORICAL POPULATION ESTIMATES**



Existing Population Forecasts

Water Source/Demand Study

The Water Source/Demand Study (Cunningham Associates, 1993) provides population projections based on regional forecasts prepared by Metro in 1989. The Metro forecasts utilize the inventory of developable lands within the City limits to predict ultimate population for the City. Population at buildout is estimated to be 23,847 within the current City limits.

The 1993 Study also estimates the impact of population growth in two major unincorporated areas contiguous to the City's boundary. These unincorporated areas have been designated in previous plans as "Area A" and "Area B". The location of these areas is shown in Figure 2-2. These areas have been designated by the City and by Clackamas County as "Dual Interest Areas". The City will lead in providing urban services to these areas. Thus, they must be considered in the development of population and water demand projections.

Metro estimated the buildout population of Areas A and B based on aerial surveys of undeveloped land in 1990, zoning designations and assumptions of density for different types of dwelling units. According to these estimates, an additional 2,750 persons must be served at buildout assuming full annexation of these areas, bringing the total service population at buildout to 26,597.

Milwaukie Comprehensive Plan

The Comprehensive Plan has estimated a population for the year 2005 of 20,300. This figure is based on projections supplied by Metro in 1987. This projection results in a very low growth rate, about 0.05 percent per year, between 1998 and 2005.

City staff have also estimated the number of new dwelling units that will result from full development of vacant buildable lands within the City (revised April 1999). As described in the Comprehensive Plan, at the time of full development a total of 2,827 new dwelling units will be added to the City's housing stock. The Regional Center is expected to accommodate about 63 percent of these new units through infill and redevelopment, while vacant land outside the Regional Center will absorb the remainder of the new units.

Based on the City's estimate of new dwelling units in each residential zone, a total of about 2,391 persons will be added to the City's population through full development of vacant lands outside the Regional Center. Another 2,586 people will be added by redevelopment of higher density, multifamily units inside the Regional Center. The total population at buildout within the City boundaries is thus projected to be 25,199.

Considering the previously described Metro projections for development in Areas A and B, an additional 2,750 people will exert demand for water in these areas at buildout. Thus the total buildout population for the City and contiguous areas is 27,950. This number is about

five percent higher than the projection given by the Metro aerial lands survey conducted in 1990.

Other Population Forecasts

Rate of Growth Projection

Another method of population forecasting for the City is to assume that future growth will be similar to past growth. Between 1990 and 1999, the population served by the City's water system grew from 18,670 to 20,075, for an average of 156 persons per year, or about 0.8 percent growth per year. If that same average were to continue to the year 2015 (the assumed buildout for the Water Master Plan) then the 2015 population would be about 22,804. Combined with projections for development in Areas A and B, the total buildout population for the City and contiguous areas becomes **25,554**. This about four percent lower than the estimate provided by Metro in the 1993 Water Source/Demand Study.

Recommended Population Forecast

The results of the various population forecasts are summarized in Table 2- 2. The three estimates given by the 1993 Source/Demand Study, the Milwaukie Comprehensive Plan and the Rate of Growth projection are fairly comparable, varying within ten percent of each other. Population projections are illustrated graphically in Figure 2-3.

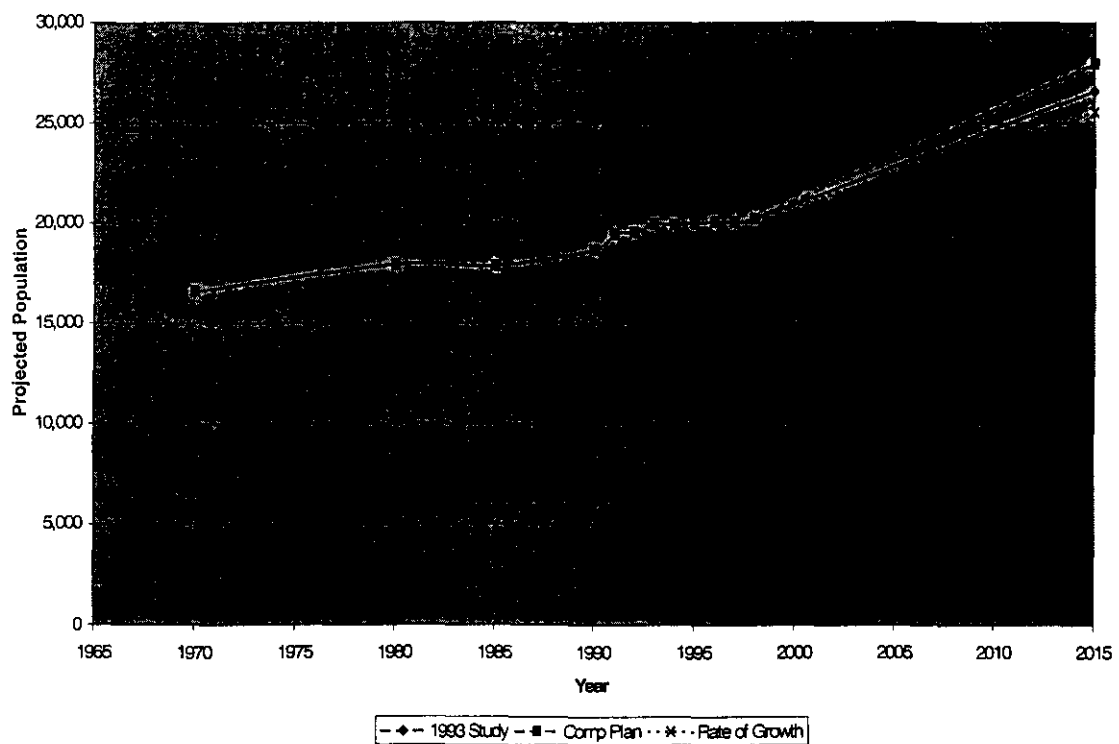
It is recommended that a total population of 27,950 be considered as the build out projection for the purposes of this Water System Master Plan. This estimate is based on a detailed residential development analysis conducted by the City in 1998, and incorporates the most rigorous analysis of future development within the City that is available at this time. This estimate, based on the City's Comprehensive Plan, is consistent with historically observed low growth rates in Milwaukie in the 1990's. This estimate is also consistent with previous Metro projections, although it is slightly more conservative in terms of water supply planning in that it gives higher population and therefore higher projected water demands.

It should be noted that this estimate is a prediction based on the best information available at this time, and should be subject to continuous updating and adjustment based on the actual population growth that the City experiences over time. This number assumes that buildout will be achieved by the year 2015, based on the limited stock of available land within the City, and the observed growth rates in the Portland area. This number also assumes that the City will fully annex Dual Interest Areas A and B by the year 2015, and will provide water service to these areas.

**TABLE 2-2
CITY OF MILWAUKIE
SUMMARY OF POPULATION FORECASTS
AT 2015/BUILDOUT**

SOURCE	City	City Plus Areas A&B
1993 Source/Demand Study	23,850	26,600
Comprehensive Plan	25,200	27,950
Historic Rate of Growth	22,804	25,554

**Figure 2-3
Summary of Population Projections**



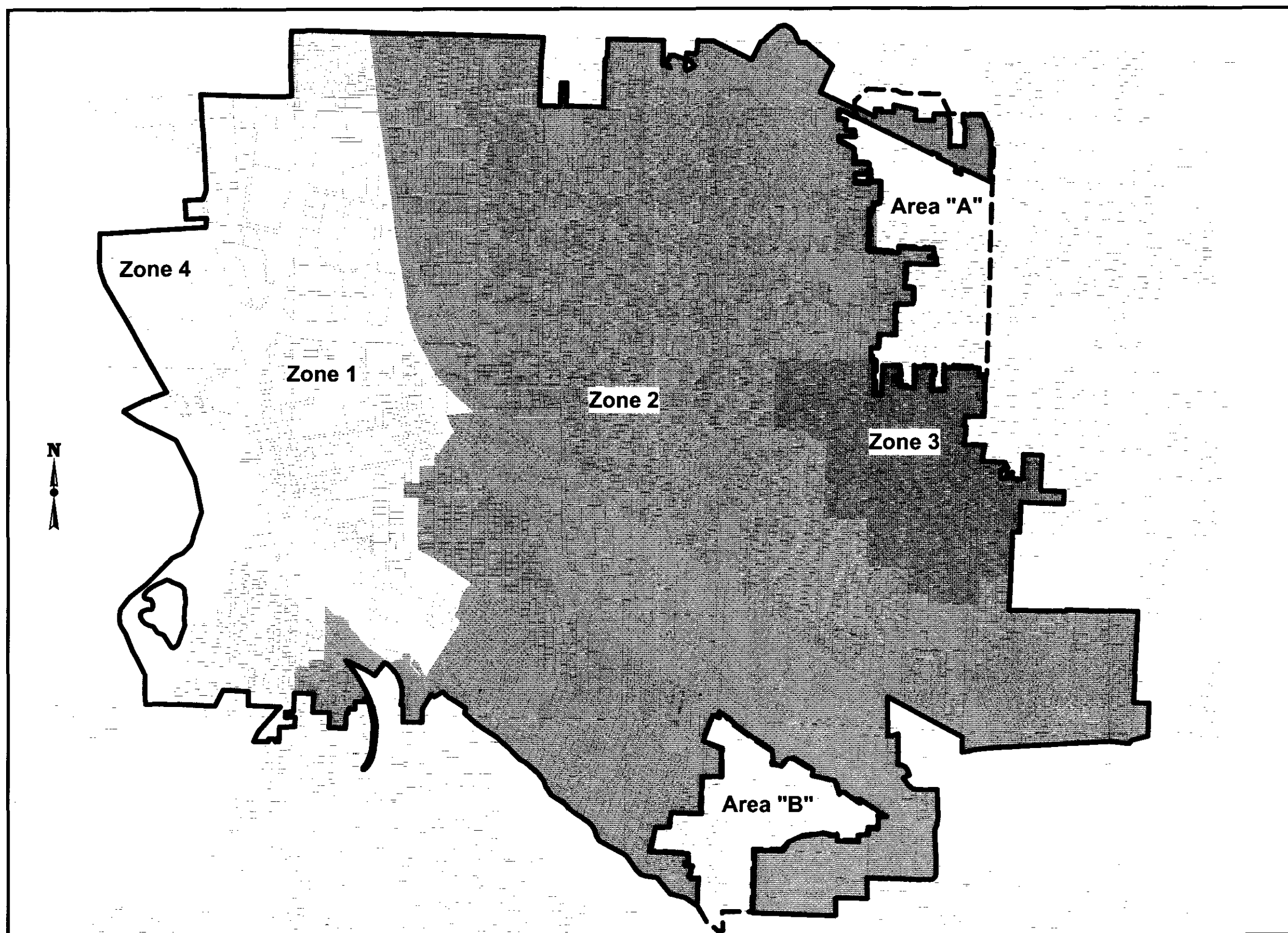


FIGURE 2-2
CITY OF MILWAUKIE
PRESSURE ZONES AND SERVICE AREAS

 Milwaukie City Limits
 Dual Interest Areas

SECTION 3 – WATER DEMAND PROJECTIONS

In Section 2, population forecasts for the City of Milwaukie to the year 2015 were presented, corresponding to the assumed year of ultimate buildout for the City. In this Section, those population projections are utilized along with historical water demand information for Milwaukie to forecast future water demands. These demand forecasts will be utilized in the facilities planning for the Water System Master Plan.

The term “demand” refers to all the water requirements of a water system including domestic, commercial, municipal, irrigation, institutional and industrial as well as unbilled, unmetered and unaccounted-for water. Demands are discussed in terms of gallons per unit of time such as gallons per day (gpd), million gallons per day (mgd) or gallons per minute (gpm). Demands are also related to per capita use as gallons per capita per day (gpcd).

The level of effort and sophistication that goes into estimating water demands can vary substantially. The demand projections in this Section rely upon historical information from the City and engineering judgment. In making a projection, it is important to understand the use of that projection. For this Water System Master Plan, the demand projections must be large enough so that the facilities that are planned will be adequate to cover future water needs in the community. At the same time, the demand forecast must not be too large, as then the planned facilities will also be too large and unnecessarily expensive. The balance between these two concerns must be found. It is also important to understand that these projections are for planning purposes only. The final sizing and capacity of the recommended facilities should be evaluated against growth trigger points and reviewed during individual project predesign to determine their appropriate sizing and other design criteria.

Historical Water Demands

Table 3-1 shows historical water production figures for the years 1991 to 1999. Annual, maximum monthly and maximum daily production data are shown in this Table. The population values in this Table are from the Center for Population Research and Census at Portland State University for the city limits of Milwaukie as listed in Table 2-1. Per capita demands are calculated by taking the production numbers and dividing by the corresponding populations. These per capita usage rates include all residential, commercial, municipal, industrial and institutional uses, as well as unaccounted-for water. The per capita consumption figures are calculated as a citywide average. There may be significant variation in per capita consumption within areas of the City depending on nature of the development present, the amount of new development compared to established development, and other factors. These figures include demand exerted by large portions of Area A, even though most of this area has not yet been annexed into the City. Some demand is also being exerted by Area B, although much of this area is currently being served by Clackamas River Water (CRW).

**TABLE 3-1
HISTORICAL WATER DEMANDS WITHIN MILWAUKIE CITY LIMITS**

YEAR	POPULATION	ANNUAL AVE DEMAND MGD	MAX MONTHLY DEMAND MGD	MAX DAILY DEMAND MGD	RATIO OF MAX TO AVE ANNUAL DEMAND		PER CAPITA DEMAND		
					MAX MONTHLY	MAX DAILY	AVERAGE ANNUAL GPCD	DAY MONTHLY GPCD	MAX DAILY GPCD
1991	19,450	2.65	4.1	5.27	1.55	1.99	136	211	271
1992	19,550	2.68	3.96	5.74	1.48	2.14	137	202	294
1993	19,955	2.56	3.14	4.61	1.23	1.80	128	157	231
1994	19,930	2.67	4.23	5.41	1.58	2.03	134	212	271
1995	20,015	2.59	3.53	4.00	1.36	1.54	129	176	200
1996	20,065	2.75	3.91	4.89	1.42	1.78	137	195	244
1997	20,055	2.54	3.97	4.92	1.56	1.94	127	198	245
1998	20,220	2.47	3.87	5.14	1.57	2.08	122	191	254
1999	20,075	2.52	3.45	4.50	1.40	1.80	126	172	224

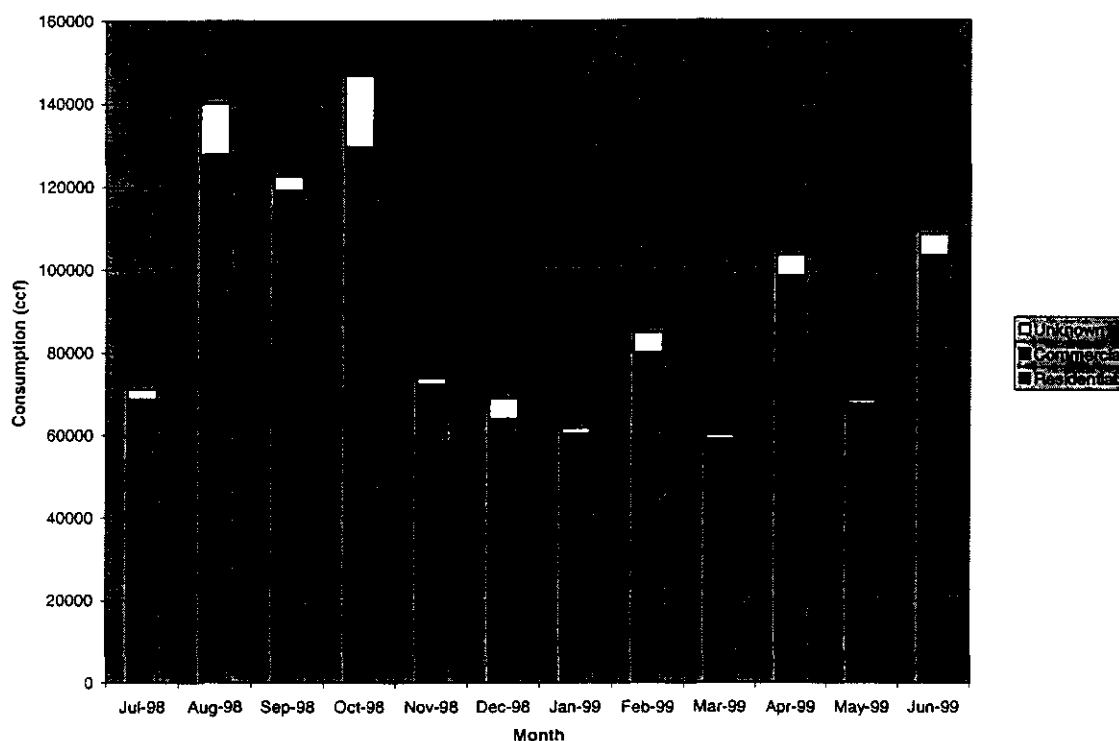
note: original data was not provided for years 1991, 1992. Figures taken from 1993 Water Source/Demand Study

As can be seen in Table 3-1, the peak day per capita consumption in Milwaukie varies considerably over this period, from a low of 200 gpcd to a high of almost 300 gpcd. For comparison purposes, the peak day per capita consumption over the same period for Oregon City varied from 285 to 381 gpcd, and for the City of West Linn it ranged between 249 to 335 gpcd. For 1994, the per capita consumption in the South service area of Clackamas River Water was 342 gpcd. While a variation of 100 gpcd over the eight year period of record is common, as can be seen by comparing Milwaukie with neighboring cities, Milwaukie's per capita consumption was at the low end of the range observed in surrounding small cities. No year in the last decade has seen a per capita consumption above 300 gpcd. This low per capita usage reflects Milwaukie's character as an older, fully developed community. In newer, growing communities, residential construction, development and irrigation are major water users. Milwaukie's per capita consumption figure is consistent with an established city, and is more similar to that observed in the City of Portland.

Distribution of Water Consumption by Customer Class

City staff prepared estimates of water consumption by customer class for the most recent fiscal year, from July 1998 to June 1999. Water consumption in Milwaukie is primarily residential, averaging about 80 percent residential to 20 percent commercial consumption in 1998/1999. Figure 3-1 illustrates the monthly distribution of consumption between residential and commercial accounts. The relative fraction of residential versus commercial use appears to have remained stable over the last decade. The 1993 Water Demand/Supply Study indicated 81 percent residential use and 19 percent commercial use for the year 1991.

**FIGURE 3-1
CONSUMPTION DISTRIBUTION**



Unaccounted-for Water

Unaccounted-for water is measured as the difference between water produced and water sold. Water loss is typically attributed to unmetered water delivery, inaccurate metering equipment or system leaks. Acceptable water losses industry-wide are considered to be less than 15 percent.

Monthly billing and production records were compared for the most recent fiscal year from July 1998 to June 1999. The percent difference between water delivered to the system and water consumed over this 12 month period was very low, about 5 percent. The City's own internal estimates of unaccounted-for water indicate losses averaging about 10 percent per year.

Milwaukie has reduced its unaccounted for water over the last decade through a program of meter replacement, water main replacement and leak repair. Out of a total of 6,500 residential meters, about 6,000 of these have been replaced in the last five years. Milwaukie has also opted to contract its meter reading to a private service, Meter Readers, Inc. of Lake Oswego. The City has estimated that use of the service has reduced meter-reading errors and has resulted in labor cost savings. Annual cost of the meter reading service is about \$15,000. The City also maintains an aggressive program of water main replacement, and annually budgets \$300,000 to \$400,000 for replacement of aging water mains. The observed

incidence of leaks has declined over the past several years, according to City staff estimates. These efforts appear to be paying off in terms of reducing water loss. Current water losses probably range between five and ten percent. The 1993 Water Demand/Supply Study indicated an unaccounted for water figure of 15 percent for the year 1991.

Water Demand Forecasts

Per Capita Consumption

The water demand forecasts that are developed in this study will be used in planning for future upgrades and expansions of the City of Milwaukie's water supply system. If the water demand forecasts are too far above the actual future water demand, then there is a danger that the facilities that are planned for the future will be larger and more expensive than needed. If the demand projections are too far below the actual future water demand, then there is the danger that the facilities that are planned for the future will be inadequate.

Predicting future water use has several inherent uncertainties. Per capita consumption in a community is influenced by many factors and can vary widely even between adjacent neighborhoods. Among the factors which cause this variability are the relative mix between residential, commercial and industrial users; the amount and type of landscaping; the area of lots which are irrigated; the use of automatic irrigation systems; the kind of irrigation systems that are used; the age of plumbing facilities in homes; the size of families in the neighborhood; and the amount of multifamily housing compared to single family housing. In addition, the peak demand in any given year is greatly influenced by the weather. The amount and frequency of summer rains and the temperature and duration of summer hot spells will vary substantially from year to year. Thus, the per capita consumption in any community can vary significantly from year to year as shown in Table 3-1.

Possible future changes in per capita consumption can occur due to conservation programs, the reduction (or increase) in unaccounted-for water, and changes in the mix of residential, industrial, and commercial water use. This latter change can occur if a large manufacturing facility were to locate in or leave the City. The water demand characteristics of future residential growth also may not replicate the water demand characteristics of historical residential use, due to differences in lot sizes, landscaping, and the number and nature of water using fixtures. Denser development tends to have lower per capita consumption than more spread out development. New neighborhoods tend to have higher per capita consumption than more established neighborhoods due to construction activity, new lawns, and a greater prevalence of automatic sprinkling systems.

As shown in Table 3-1, the recent historical average daily per capita demand ranged from approximately 122 gpcd in 1998 to approximately 137 gpcd in 1992 and 1996, a variation of about 12 percent. The average per capita demand over this period was 131 gpcd. As can be also be seen from this Table, the estimated peak day per capita consumption for the City as a whole varied from a low of 200 gpcd in 1995 to a high of 294 gpcd in 1992, a variation of about 50 percent. Three of the eight years shown in this Table have a City-wide peak day

consumption between 244 and 254 gpcd, with two years being below this range and three years being above this range.

While the peak day per capita consumption can vary significantly from year to year due to the weather, there tends to be an upper limit in a community to the per capita consumption. Based on the distribution of the citywide values, it would not be unreasonable to expect peak day per capita consumption values up to approximately 5% higher than shown in this Table 3-1 under extreme weather conditions. Thus, the citywide peak day per capita consumption could reach 300 gpcd in an extremely hot year.

Recommended Per Capita Consumption

The decision as to which peak day per capita consumption value to use relates to the desired level of system reliability. There is often a relationship between the level of reliability and cost - higher levels of reliability result in higher costs. The reliability of local distribution system components, such as transmission and distribution pipelines and local pump stations and tanks, tend to be designed toward the upper end of a reliability range. Using a higher level for peak day per capita consumption provides a higher degree of certainty that even in the most extreme weather conditions, adequate water will be available. This higher consumption value will result in more costly facilities, however. Other methods of dealing with extreme peaks in demand include reliance on temporary curtailment of water use or interties to other sources.

For the purposes of this plan, it is recommended that 280 gpcd be used for peak day consumption for the year 2015 demand projection. This figure is at the high end of historically observed per capita consumption, and provides some system reliability to accommodate hot and dry weather. It also reflects Milwaukie's status as a stable, developed community that will grow mostly by redevelopment and infill over the next 15 years.

For the purposes of this plan, it is also recommended that the future average daily per capita demand be assumed to be 140 gpcd. This is slightly more conservative than the arithmetic average of the average daily per capita demand of 131 gpcd, observed over the eight-year period of 1991 through 1998. The peaking factor, defined as the ratio of average to peak daily demand then becomes 2.0, which is a reasonable and commonly used peaking factor.

It must be recognized that these estimates are predictions based on the best information available at this time, and should be subject to continuous updating and adjustment based on the actual water demand that the City experiences over time.

Projected Water Demand

The future water demand forecast is obtained by multiplying the recommended per capita usage rate discussed above by the recommended population forecast from Section 2. The results of this calculation are shown in Table 3-2. This estimate includes Areas A and B, and assumes that these areas will be fully developed by 2015 and that the City of Milwaukie will provide water service to these areas.

**TABLE 3-2
CITY OF MILWAUKIE
SUMMARY OF PROJECTED WATER DEMANDS**

YEAR	2015/Buildout
POPULATION	27,950
PEAK DAY PER CAPITA CONSUMPTION (GPCD)	280
AVERAGE DAY PER CAPITA CONSUMPTION (GPCD)	140
AVERAGE DAILY DEMAND (MGD)	3.91
PEAK DAY DEMAND (MGD)	7.83

Previous Water Demand Forecasts

The 1993 Water Source/Demand Study presented demand forecasts at buildout for the City of Milwaukie. This study predicted an average day water demand of 3.64 mgd, including full development of areas A and B. This is slightly lower than the current recommended projection of 3.91 mgd. There are two reasons for the difference in projections. The 1993 Study projected a buildout population about five percent lower than the one recommended for this Master Plan. The current projection is based on the City's Comprehensive Plan evaluation of remaining buildable lands, conducted in 1998. The 1993 Study also used a slightly lower per capita figure of 137 gpcd, versus the 140 gpcd recommended for this Master Plan.

The 1993 Study projected a peak day demand of 8.75 mgd at buildout. This is higher than the 7.83 mgd recommended in this Master Plan. The 1993 Study applied a peaking factor of 2.4 to calculate peak day demand based on average day demands. As discussed above, this factor is unnecessarily conservative. Recent years have seen more emphasis in conservation and wise water use. The Portland region has experienced success with trimming the summertime peaking factor through public education campaigns. These efforts were undertaken in response to the drought years, particularly the summer of 1994. The City of Milwaukie showed a 25 percent drop in per capita water demand in 1995, presumably in

response to intensive conservation messages. These conservation messages are still effective. While per capita consumption has been climbing since 1995, it has not reached pre-drought levels.

The 2.0 peaking factor recommended in this Master Plan is more appropriate for a mature community, while still providing system reliability in peak use periods. This factor is more consistent with the current emphasis on conservation and water-efficient fixtures. This factor will remain appropriate, as Milwaukie continues to develop at higher density in the Regional Center. Higher-density development typically uses less water per capita because of lower landscaping requirements. New development also reduces per capita consumption as more water-efficient fixtures are installed.

The Regional Water Supply Plan (RWSP) developed long range water demand forecasts for water providers in the Portland Metro area, to the year 2050. These forecasts were developed in the early 1990's based on predicted land use and growth patterns. The RWSP forecast for Milwaukie is overly conservative, predicting a 1998 peak day demand of 8.9 mgd, compared to an actual peak day use of 5.14 mgd in that year. The RWSP predicted peak day use for 2015 is 9.34. This is about 1.5 mgd higher than the recommended figure of 7.83 mgd. The RWSP projections flatten out over time as the projected growth curve for the region flattens out, so that the RWSP numbers may become more accurate over time.

SECTION 4 – PLANNING CRITERIA

This Section presents the planning and analysis criteria that are recommended for the evaluation of existing facilities, and for new facilities planning for the City of Milwaukie. It must be recognized that these planning criteria are not hard and fast rules that must be exactly adhered to in order to provide a reliable water system. They are simply standards by which the system can be judged for the purposes of planning capital improvement and capital maintenance projects under most circumstances. There may be instances where deviations from these criteria are reasonable and justifiable based on specific circumstances. In addition, it may be appropriate for the City to have specific Design Code requirements that deviate from these master planning criteria. The City should review its Design Code and determine whether changes are appropriate to it once this Water System Master Plan has been adopted.

Planning Period

This Water System Master Plan covers a 15-year period to the year 2015. This corresponds to the year of projected ultimate buildout for the City. This Master Plan identifies any deficiencies which may exist in the current system. A detailed system evaluation has also been conducted based on the projected population at the year 2015. The impacts to the water system from growth and development in the community are analyzed over this time period. Also in this time period, the staging of facilities corresponding to incremental levels of growth have been evaluated. It is important to note that improvements should be timed based on the actual population growth which occurs, and not on the specific years listed in this Water System Master Plan.

Planning Area

The planning area for the Master Plan is the limit of the current City of Milwaukie water system, plus Dual Interest Areas A and B. It is assumed that these areas will be annexed and fully developed by the year 2015, and that the City of Milwaukie will provide water service to these areas.

Design Criteria

Service Pressure

The minimum pressure that must be maintained in the system per State of Oregon Health Division (OHD) standards is 20 pounds per square inch (psi) (46 ft). This pressure must be maintained even during a fire flow event on a peak demand day. The existing system has been designed around tank and reservoir elevations that typically provide maximum and minimum service pressures between 170 psi (393 ft) and 45 psi (104 ft) respectively. The typical operating pressures obtained from the existing tanks and reservoirs should be maintained. Each of these pressure conditions will be evaluated with system reservoir/tank levels three-fourths full.

Source

The main source of supply should be capable of providing the projected peak day demand. It should meet this demand with firm capacity - that is, with the largest pump, filter or other component of the system out of service. The City should also have an emergency source of supply that is capable of providing the average day demand for the length of time that the primary source of supply is out of service, such period lasting up to a week. This emergency source could be provided through an intertie, storage, a secondary source, or other methods.

Transmission Pipelines

Transmission pipelines are considered as those greater than or equal to 10-inches in diameter. Pipeline flow velocities in transmission pipelines should be less than 5 feet per second (fps). All water transmission pipelines greater than or equal to 18-inches in diameter should be capable of providing peak day demands. All other transmission pipelines should be capable of supplying peak hour demands.

Distribution Pipelines

Distribution pipelines should be sized to serve peak hour demands and fire flow requirements with system reservoirs/tanks three-fourths full. Flow velocities for a distribution system pipeline should be below 10 fps and headloss in the pipeline should be below 10 ft per 1000 ft of pipeline. Minimum pipeline diameter for new distribution pipes will be 6-inches. Pipeline diameters smaller than 6-inches will be identified as inadequate for fire flow conditions. Any pipeline below 6-inches should be upgraded before being equipped with a fire hydrant. A 6-inch line with a fire hydrant should be part of a looped system or be no more than 500 feet in length.

Pressure Reducing Stations

Pressure reducing stations should meet the criteria of supplying the peak hour demand within the continuous flow rating of the valve. The fire flows through a pressure reducing station should be adequately delivered within the intermittent flow rating of the valve.

Pump Stations

Pump stations should be sized for a firm capacity equal to the peak day demand. Firm capacity is defined as the capacity of the pump station with the largest pump out of service.

For reliability, power supplies to pump stations should have either two sources of primary power feed, or one main source and standby or emergency power. The secondary power supply should be sized so that available pumping capacity is equal to average day demand, or fire flow, whichever is greater.

Storage

Storage facilities in water systems are generally provided for four purposes - equalization storage, operational storage, fire storage, and emergency storage. The total storage required in any tank or reservoir is the sum of these four components plus the dead storage (the volume of the tank that is unavailable to use due to physical constraints). The components of storage are described as follows:

Equalization Storage. This storage is needed in a water system to meet water system demands in excess of the transmission/pumping delivery capacity from the supply source to the reservoir. The volume of equalization storage required is a function of supply system capacity, transmission piping capacity between reservoirs and pump stations, and system demand characteristics. Equalization storage is generally less expensive to provide than increased treatment, pumping and transmission piping capacity beyond that required to meet maximum day demands. Equalization storage volume should be sufficient to meet demands in excess of the maximum daily demand. Equalization storage volume in the amount of 20 to 30 percent of maximum daily demand is typical, and for this Master Plan, 25 percent of peak day demand is assumed for equalization storage.

Operational Storage. This storage may be needed if the supply source does not continuously deliver supply. Operational storage would be required, for example, if the supply system were only operated over part of a day with the supply coming from storage during the remaining part of the day. The City of Milwaukie, however, does not operate its distribution system in a manner that requires additional operational storage beyond equalization storage, and thus, no additional operational component of storage is recommended in this Master Plan.

Fire Storage. Fire storage is provided to meet the single most severe fire flow demand within the system or pressure zone served by the storage facility. The fire storage volume required is determined by multiplying the fire flow rate by the duration of that flow.

Residential fire flows are 1,000 gpm for 2 hours and can be applied at any fire hydrant in the pressure zone. Commercial, industrial, and multi-family fire flows can be applied at any fire hydrant within areas that have appropriate land use zoning and may be specific to the zoning and actual facilities in place. A fire flow of 5,000 gpm for 10 hours is a conservative upper limit on storage requirements for zones with commercial, industrial and multi-family uses.

Emergency Storage. This storage is provided to supply water during emergencies such as power outages, equipment failures, pipelines failures or natural disasters. The amount of emergency storage provided can be highly variable and is dependent upon an assessment of risk and the desired degree of system reliability. Detailed vulnerability analysis and risk assessments are not within the scope of this study. An emergency supply equal to one day of average demand within a pressure zone is considered typical for most distribution systems and is appropriate for the City of Milwaukie's system based on the summary vulnerability analysis.

It is also desirable, although not required, that storage be provided from at least two separate storage reservoirs or is available through pumping or gravity from a secondary reservoir at a

different elevation. This provides for continuous operations during maintenance, repairs or reconstruction or modifications to any single reservoir.

Summary of Storage. Based on the above criteria, the required storage in each pressure zone will consist of 25% of projected peak day demand for equalization plus the fire flow demand plus one average day demand for emergencies. This is comparable to the storage requirements set forth in the 1993 Water Source/Demand Study.

SECTION 5-EXISTING SYSTEM DESCRIPTION

General System Description

The City of Milwaukie is supplied with groundwater through a series of eight wells scattered throughout the City. Groundwater is pumped from the Troutdale Aquifer. This extensive aquifer underlies the Portland/Vancouver area and consists of several layers. Noteworthy units in the aquifer include the Troutdale Gravels and Troutdale Sandstone formations. The City of Portland taps this aquifer at its Columbia River Wellfields, and cities in southern Clark County Washington rely on this aquifer as their primary source of supply.

Total groundwater production capacity is about 5.8 mgd, with individual wells ranging in capacity from 400 to 1,000 gallons per minute (gpm). The City maintains two air-stripping facilities for the removal of low levels of volatile organic chemicals from the groundwater. The City currently supplements its groundwater supply by purchase of surface water from Clackamas River Water (CRW). Approximately 0.5 million gallons per day (mgd) of surface water has been purchased from CRW since August of 1998.

The City of Milwaukie's water system includes:

- a system of seven operational groundwater wells scattered throughout the City, with two central treatment facilities;
- approximately 100 miles of distribution and transmission pipelines,
- three reservoirs totaling 6.0 million gallons in storage, groundwater pumps, a pumping station, pressure reducing valves, and other facilities.

The City also maintains emergency interties with the City of Portland and the Oak Lodge Water District. Milwaukie is in the process of constructing a new intertie with Portland, at the north end of the city. Improvements would need to be made to an old intertie with Oak Lodge at the south end of the city in order to make this operational.

Supply System

The City of Milwaukie was established as a small settlement on the banks of the Willamette River in the 1800's. It remained a small town until the war years spurred the development of industry and a manufacturing job base in the City. In the 1950's, population growth spreading from Portland further swelled the City's size and area. The first groundwater wells for industrial and municipal water service were drilled in 1935-36 (Wells 1 and 2). Well 3 was completed in 1946. Two more wells were drilled in the early-1960's (Wells 4 and 5), and another two were developed in the early 1980's (Wells 6 and 7). Milwaukie developed its last groundwater well in 1985 (Well 8). Individual well capacities range from 475 gallons per minute to 1,000 gallons per minute. Total groundwater production is about 5.8 million gallons per day. Table 5-1 summarizes the City's groundwater development and water rights.

**TABLE 5-1
SUMMARY OF GROUNDWATER DEVELOPMENT**

Well #	Year Constructed	Current Capacity		Water Right
		(gpm)	(mgd)	(gpm)
1	1935	0	0	380
2	1936	449	0.63	380
3	1946	528	0.76	380
4	1960	478	0.69	500
5	1963	650	0.94	716
6	1982	710	1.02	806
7	1982	939	1.43	1,195
8	1985	442	0.64	725

At the present time, the capacity of two of the City's wells is greater than the water rights established for these wells. Well 2 has a permitted water right of 380 gpm, but is capable of producing 450 gpm. Well 3 has a permitted water right of 380 gpm, but is capable of producing 530 gpm. If these wells were operated to their capacity, an additional 0.31 million gallons per day (218 gpm) could be made available for water supply. This would amount to a five percent increase in total production capacity. The City of Milwaukie should apply for additional water rights from these wells to utilize their additional capacity. An additional water right of 70 gpm would be required for Well 2, and an additional water right of 148 gpm would be required for Well 3. The current capacities of the City's other wells are below their permitted or certificated water rights.

Several wells (wells 1, 2, 3 and 8) are permitted, but the City has never gone through the certification process to perfect the water rights for these wells. Certificated water rights should be obtained for the operating wells.

Currently, there is no limitation on the amount of groundwater that the City may withdraw, within its permitted water rights. In other parts of the State, and even in the metro region, Critical Groundwater Areas have been designated by the Oregon Water Resources Department (OWRD). In these areas, the pumping of groundwater has exceeded the natural replenishment of the supply. A Critical Groundwater Area designation restricts the amount of water which may be withdrawn and establishes preferences for its use, regardless of established water right priority dates. In the Portland area, the Cooper-Bull Mountain groundwater area southwest of Beaverton-Tigard has been designated as a Critical Groundwater Area.

The northern Willamette Valley relies primarily on the Troutdale Formation and the Columbia River Basalt group for groundwater production. In 1992, the OWRD established eleven "groundwater limited areas" in the northern Willamette Valley. Groundwater

declines have been observed in these areas as a result of heavy pumping. In the Metro region, the groundwater limited areas include Sandy-Boring, Damascus, Sherwood, and Dammasch-Wilsonville.

The most recent available information indicates that groundwater levels in the Milwaukie area are not experiencing long term declines due to existing uses. Therefore, restrictions on existing water rights are not anticipated within the time frame of this Master Plan. Groundwater development will be considered as an option to meet future water demands.

A connection to the Clackamas River Water (CRW) system was constructed in 1997. The intertie has a firm capacity of 1.0 mgd and an ultimate capacity of 2.0 mgd, and is located at SE Harmony Road near SE Fuller Road in Milwaukie. A formal agreement for the purchase of surplus water by Milwaukie was established in 1997. This 20-year agreement specifies that Milwaukie will purchase surplus water from CRW at a constant amount of 0.5 mgd throughout the year. Between May and September, the purchase is restricted to this uniform rate of approximately 350 gallons per minute (gpm). Outside these months, the total volume remains fixed at 0.5 mgd, but the flow rate may vary throughout the day provided demand does not cause undue stress to the CRW system.

In 1998, approximately 20 percent of Milwaukie's annual average demand was met by CRW supply, and 10 percent of the peak day demand was satisfied by CRW supply. The remaining demand was met by the City's groundwater supply.

Groundwater Characteristics

Milwaukie's water supply wells tap the Troutdale Aquifer Group, a large aquifer covering 500 square miles in Multnomah, Clackamas and Columbia Counties in Oregon and Clark County in Washington. The aquifer consists of distinct hydrostratigraphic layers, which include the Troutdale Gravel Aquifer and the Troutdale Sandstone Aquifer. These extensive aquifers are overlain by unconsolidated sedimentary deposits. The majority of Milwaukie's wells are completed in the Troutdale Gravel Aquifer, which varies from 50 to 300 feet below sea level. The City of Portland taps the Troutdale Aquifer in its Columbia River wellfields, and major water suppliers in southern Clark County rely on it as their primary source of supply.

Groundwater levels in the Milwaukie area are not experiencing declining water levels due to over-pumping. In terms of quantity at least, groundwater is a reliable and abundant water supply option for the City. Additional groundwater supply has been proposed as a future water supply option in the 1993 Water Source/Demand Study (Cunningham Associates).

Groundwater Quality

As a public water provider, the City is required by the Oregon Health Division to monitor and report the results for more than 100 regulated and unregulated inorganic and organic

compounds. Monitoring for lead and copper, microbiological and radiological parameters is also required.

General groundwater quality can be characterized by its mineral content, pH, hardness and nitrate content. Inorganic characteristics within the City's wells indicate ground water quality is generally good. Table 5-2 lists the most recent results of inorganic monitoring. Sampling for inorganics is required every three years. Arsenic was detected at a maximum level of 5.0 ug/L, well below the current MCL of 50 ug/L. The arsenic standard is under revision at this time. A draft arsenic standard of 5 ug/L has recently been proposed by EPA, and the proposed new Rule will appear for public comment in the Federal Register in early June of 2000. The EPA is also asking for public comment on possible MCL's of 3 ug/L, 10 ug/L and 20 ug/L. Public comment on the revised standard will be due to EPA 90 days after publication of the draft Rule. Best Available Technologies (BAT's) for this contaminant are ion exchange, activated alumina, reverse osmosis, modified filtration, modified softening processes and electrodialysis. The City will need to monitor the final outcome of the arsenic standard before determining the extent of impact to its system. Additional sampling for arsenic should be conducted to develop more information on arsenic levels in groundwater, in anticipation of upcoming regulatory changes.

**TABLE 5-2
RESULTS OF INORGANIC MONITORING
UNTREATED GROUNDWATER**

	Range (mg/L)		MCL (mg/L)	Sample Date
	Max	Min		
pH	7.76	6.6	NA	11/23/88
Hardness	85.5	31	NA	11/23/88
Cadmium	0	0	0.005	7/29/97
Manganese	0.033	0.028	NA	11/23/98
Iron	0.44	0.10	NA	11/23/88
Nitrate	5.0	0	10	6/28/99
Sulfate	17.0	0	NA	7/29/97
Chloride	5.5	3.5	NA	11/23/88
Barium	0.17	0	2.0	7/29/97
Arsenic	0.005	0	0.05	7/29/97
Sodium	8.5	6.9	NA	7/29/97

Nitrates were detected in approximately 80 % of the samples collected and ranged from 5.0 mg/L to 0 mg/L. High levels of nitrates usually indicate nitrate contamination from leaking septic tanks, animal waste or fertilizers. The City has been and continues to be in compliance with the nitrate standard.

Current radiological testing includes gross alpha activity. Gross alpha activity results indicate low levels within the groundwater. The City plans to conduct an initial sampling for radon in 2000. Radon is naturally occurring in groundwater. The anticipated revised standard for radon is 300 pCi/L, to be promulgated in 2001.

Since the discovery of Tetrachloroethylene (PCE) and Trichloroethylene (TCE) contamination within the City's wells in 1988, the City has conducted monitoring in an effort to identify the source and movement of the contamination. In 1992 the City installed packed tower aeration at wells No. 2, 3, 4, 5 and 7 to remove the contaminants from the water. In accordance with the Oregon Health Division, monitoring of treated water is conducted on a quarterly basis. Monitoring indicates that TCE and PCE levels have decreased significantly with treatment. The City continues to be in compliance with the regulated concentration levels and reporting requirements. In the raw water sampling, there have been no significant changes in concentration levels since the contamination was first discovered.

Wellhead Protection

The 1996 Safe Drinking Water Act Amendments allocated resources to the State for drinking water protection. Important components of the drinking water protection program are source water assessments and the development of drinking water protection plans. The City of Milwaukie will receive financial and technical assistance from the Oregon Health Division and the Department of Environmental Quality for source water assessments. The OHD has begun conducting source water assessments for the 2,735 public water systems in Oregon. These assessments must be completed by 2003. Technical work completed in the assessment phase includes "delineation", where the area that serves as the source of the public water supply is defined for both surface and groundwater supplies; "inventory", in which potential risks and contamination sources are identified; and "susceptibility analysis", in which those areas most vulnerable to contamination are identified.

The OHD has indicated that Milwaukie is on OHD's priority list for completion of this work due to past groundwater contamination, and anticipates that OHD will initiate work on Milwaukie's supply assessment by Fall of 2000 (Nelson, personal communication, March 2000). OHD is prioritizing its efforts to those water suppliers with an active interest in conducting this work. If Milwaukie expresses such an interest, the work schedule can be accelerated. OHD will make use of past investigations and studies conducted by DEQ during the contamination investigations, but will supplement previous efforts with current information on groundwater mapping, location of potential contamination sources and vulnerability analysis. Technical assistance will also be available for those systems that choose to go beyond the assessment phase, and voluntarily develop a Drinking Water protection Program (DWPP). The purpose of the DWPP is to develop plans to reduce the risk of contamination, and to develop contingency plans in the event of loss of supply due to contamination.

Milwaukie is an excellent candidate for the development of a Drinking Water Protection program, due to its reliance on groundwater and demonstrated vulnerability to contamination – the source of which has not been determined. It is recommended that Milwaukie take an active role in completing a source water assessment for its groundwater supply, and take full advantage of all state resources available to develop a comprehensive DWPP.

Existing Supply Facilities

Groundwater Wells

The City of Milwaukie currently utilizes 7 groundwater wells. The wells are capable of producing approximately 4,196 gpm (6.1 mgd) of water. This capacity falls short of current and projected peak day demands for the City. The well sites are shown on Figure 5-1. An overall schematic of the system is shown in Figure 5-2. Table 5-3 lists the well locations and their capacities. Wells 2, 3, 4, 5, and 7 have well head pumps that deliver flow through air stripping towers to a clearwell for delivery to the distribution system. Well 6 delivers flow to the Stanley storage tank and Well 8 delivers flow directly to the distribution system.

**TABLE 5-3
GROUNDWATER WELL LOCATIONS**

Source	Location	Pumping Capacity (gpm)	Well Production (gpm)
Well No. 2	9851 SE 40 th Ave	600	380
Well No. 3	3800 SE Harvey St	NA	380
Well No. 4	9829 SE Railroad Ave	630	478
Well No. 5	9870 SE Stanley Ave	630	650
Well No. 6	11800 SE Stanley Ave	NA	710
Well No. 7	11022 SE 37 th St	NA	939
Well No. 8	5393 SE Lake Rd	750	442
Total			3979

N/A = data not available

Groundwater Treatment Facilities

Contamination of a portion of the City's groundwater supply with low levels of volatile organic chemicals was detected in 1988. The groundwater system was taken off-line during the investigation, and areas of contamination were defined. Contaminants were confirmed in five of the City's seven production wells. Working in coordination with the Department of Environmental Quality (DEQ) and the Oregon Health Division (OHD), Milwaukie installed two packed tower aeration facilities to serve the affected wells.

One air stripping facility was constructed at 40th Avenue and Harvey Street to treat water from wells 2, 3 and 5. The facility consists of three forced air, countercurrent packed tower units. Each fiber-reinforced plastic tower is designed to treat a groundwater flow of up to 600 gpm. The inner diameter of the each tower is 6 feet, and the stripping media consists of thousands of pieces of light-weight plastic units with a high surface to volume ratio. Each tower operates independently of the other two, so that individual wells can be taken off-line without disrupting operation of the treatment facility. The treatment facility is equipped with a standby generator. Treated water chlorination is provided by a gaseous chlorine injection system. Prior to construction of this facility in 1991, the City's groundwater system had been unchlorinated.

A second stripping facility was constructed for wells 4 and 7 at SE Railroad Avenue, near Oak and Monroe Streets. This facility was brought on-line in 1991 and is similar in design to the facility described above, having two packed towers for independent operation of the two wells.

Emergency Interties

The intertie currently being used for the purchase of surplus supply from CRW can also function as an emergency intertie, up to its ultimate capacity of 2.0 mgd. In the event of emergency, and subject to CRW's ability to supply the required water, Milwaukie can purchase emergency supply at a rate two times the surplus supply rate.

Milwaukie is in the process of upgrading an emergency intertie to the City of Portland's water system. The intertie will be located in Johnson Creek Boulevard at SE 45th Place. The old intertie was used to supply Milwaukie following discovery of chemical contamination in some of the City's groundwater wells in 1988. The City of Portland intertie supplied all water to Milwaukie in the winter of 1988 while the contamination event was being investigated, and provided supplemental water while treatment facilities were being constructed from 1989 to 1991.

Milwaukie and the City of Portland are currently negotiating an agreement for an improved intertie connection. The improvements include relocating the meter vault out of the Johnson Creek roadway and replacing outdated supply line from the metering facility to Milwaukie's distribution system.

Milwaukie maintains a small intertie with the Oak Lodge Water District at Where Else Lane. The connection consists of a six-inch valved connection to Oak Lodge's 16-inch supply main from Portland which runs directly north-south through Milwaukie. No metering or pressure reducing equipment is in place. This intertie would require upgrading or relocation in order to become useful as an emergency supply.

Distribution System

Distribution System Water Quality

As a public water supply system (ID Number 4100528), the City of Milwaukie must comply with the drinking water regulations administered by the Oregon Health Division (OHD). Part of these regulatory requirements include a periodic sanitary survey conducted by the State of Oregon to review the operating condition of the water system. The most recent survey was completed by the State in July, 1995 and concluded that (Letter dated July 12, 1995 from Kari Salis, to Jay Saatkamp): "The system appears to be in good operating condition".

Several recommendations were made for improvements to water quality monitoring. The City was instructed to begin monitoring for trihalomethanes, based on its size and due to the introduction of chlorine disinfection. Monitoring results were noted as past due for several water quality constituents, including lead and copper, VOC's, nitrates and radiologicals. The City was required to develop a written bacteriological sampling plan, and to monitor for distribution system chlorine residuals on a daily basis. The State also recommended that a cross connection control program be developed.

The City completes all the distribution system monitoring which is required by the State as well as additional tests which are needed to confirm adequate system operation.

- Distribution coliform samples are taken twice a month from a pool of 24 sites spread throughout the City. Twelve coliform sample locations are dedicated taps housed in underground meter boxes. The remaining twelve locations are residential hose bibs and taps inside commercial establishments. The City is required to collect 20 samples per month. No violations of the maximum contaminant level for coliform bacteria have ever occurred.
- Four chlorine residual measurements are taken in the distribution system daily. In areas that receive CRW supply, chlorine residuals tend to be higher than in other parts of the City. On the City's east side, toward CRW, distribution system residuals range between 0.45 and 0.55 mg/L. The CRW surface water supply enters Milwaukie's system with a residual of greater than 0.5 mg/L. In the western parts of the City and the northwest industrial area, residuals range closer to 0.22 to 0.27 mg/L. Low level residuals are observed in parts of the City in the range of 0.15 mg/L. In recent years, the City has attempted to maintain distribution system residuals below 0.5 mg/L in order to improve the aesthetic quality of the water for its customers. Customers reacted strongly to the introduction of chlorine to the previously undisinfected water supply in 1991, and the City received more than 50 customer complaint calls per month. The City credits an aggressive flushing program and better residual control for a reduction in the number of monthly customer complaints.

- The Oregon Health Division requires that public water systems serving a population of greater than 10,000 and that add a disinfectant to their water, monitor for Trihalomethanes (THMs) on a quarterly basis. Trihalomethanes are disinfection byproducts (DBPs) formed upon disinfection of water with chlorine. The MCL for total trihalomethanes (TTHMs) is currently set at 0.08 mg/L. Samples are collected quarterly from the distribution system and the average of the samples is recorded. Table 5-4 lists the most recent results of these compounds. The yearly average of the samples is used to determine compliance for the system. Yearly averages since 1993 ranged from 0.0001 mg/L to 0.0190 mg/L, all well below the MCL. The City received a violation in September 1999 for failure to monitor and report the results of the THM monitoring. In response, the City issued a public notice in the local newspaper. Subsequent rounds of samples were collected as required.

TABLE 5-4
TOTAL TRIHALOMETHANES (mg/L)

Sampling Date	Quarterly Average	Yearly Average
11/18/99	0.0001	0.0001
11/18/99	0.0278	0.019
6/21/99	0.003	0.003
6/21/99	0.0122	0.0122
3/1/99	0.0005	0.0005
3/1/99	0.0171	0.0171
12/1/98	0.0065	0.0065

- The Stage 1 Disinfection Byproducts Rule also targets a group of five chemicals, Haloacetic acids (HAA5). The rule establishes a maximum contaminant level (MCL) of 0.060 mg/L that must be met by December 2001. This standard is based on the average of the five chemicals. In anticipation of the new regulations, the City began monitoring for HAA5 in 1999. Quarterly samples were collected from all eight wells in the City and at one entry point to the Clackamas River intertie. None of the five haloacetic acids were found in the City's source wells. However, samples collected from the Clackamas River intertie did detect two of the five haloacetic acids, but were below the proposed MCL.
- Lead and copper "Action Levels" have been established by EPA which require water utilities to sample from customers' taps at sites with lead pipes or copper pipes with lead solder. The action level determines whether utilities need to implement corrosion control treatment to reduce leaching of lead and copper into tap water. Sampling for lead and copper is required every 3 years. Since 1993, the City has met the required 90% percentile standards for lead and copper.

The Safe Drinking Water Act (SDWA), the federal legislation which governs all water systems, was reauthorized in 1996. Over the next several years a number of new regulatory requirements for the City will come into effect as a consequence of the revised statute. Examples include the HAA regulations referred to above and a requirement for distribution of a Consumer Confidence Report summarizing water quality information about the water system, to all customers starting in 1999. The City has completed two Consumer Confidence Reports, in 1999 and 2000.

The City has a protocol for handling water quality customer complaints. The City switchboard refers water quality complaints to the Water Operations Supervisor or the Utility Specialist in charge of water quality monitoring and compliance. Routine procedure is to conduct flushing in the area and to follow up with the customer. Customer complaints are not always logged, so an incomplete record of their nature and frequency exists. The City maintains a cross connection control program. Annual testing and inspection is conducted by certified testers.

Pipelines

The City of Milwaukie's transmission and distribution system is comprised of approximately 28 miles of pipeline of greater than 10-inch diameter. Table 5-5 lists the sizes of pipe and the length of each type. The pipeline material consists of cast iron, ductile iron, concrete cylinder, and PVC pipelines. There is approximately 18.5 miles of pipeline within the distribution system that is 12-inch diameter or greater and is considered transmission pipeline. The remainder of the distribution system is less than 12-inch diameter.

**TABLE 5-5
PIPELINE SIZE AND LENGTH**

Pipe Size (inch)	Total Length of Pipeline (ft)
20	200
18	4,900
16	8,500
14	5,400
12	78,900
10	48,350
8	143,750
6	186,350
4	74,250
< 4	15,750
Total	566,350 feet (107.3 miles)

The City of Milwaukie provides water service to four distinct pressure zones. Pressure zones 1 and 2 comprise over 85% of the transmission and distribution system. Pressure zones 3 and 4 are directly fed by pressure sustaining booster pump stations and are strictly residential service.

Reservoirs and Tanks

The City of Milwaukie's storage facilities consist of two 1.5 million gallon (MG) and one 3.0 MG storage tanks for a total of 6.0 MG of water storage. Two of these storage facilities are on adjacent properties near SE 40th Avenue and Harvey Street. These two storage facilities serve the high pressure zone (Zone 2) and the low pressure zone (Zone 1). The 3.0 MG storage facility is along Stanley Avenue near Harlow Street and serves Zone 1, 2 and a pressure sustained zone (Zone 3) that lies north and east of the reservoir.

The Zone 1 reservoir is an above grade reinforced concrete structure constructed in 1923 with an overall storage capacity of 1.5 MG. This concrete storage structure has a bottom elevation of 183.5 feet and an overflow elevation of 211.0 feet. This facility has an approximate diameter of 95 feet.

The Zone 2 reservoir is an above grade steel elevated storage tank constructed in 1968. The Zone 2 reservoir has a volume in excess of 1.5 MG including the vertical inlet/outlet piping. The ground elevation is 188.0 feet and the tank bottom elevation is 251.0 feet. The overflow elevation is 292.0 feet allowing 41.0 feet of available storage depth. The diameter of the tank is approximately 86 feet.

The Stanley reservoir is an above grade steel tank constructed in 1970 with an approximate storage volume of 3.0 MG. The tank bottom elevation is 157.0 feet and the overflow elevation is 183.0 feet. This facility provides water storage to zones 2 and 3 by pumping only and cannot be fully drained to the serviced distribution system.

In 1993, Cunningham Associates performed a seismic evaluation of the elevated reservoir in Zone 2. The study concluded that the reservoir would be able to withstand an earthquake with little structural damage if it were modified according to recommendations. However, the reservoir does not have the reserve structural capacity to guarantee that no damage will occur. In the event of a major earthquake, the tank may have to be emptied for repairs. Cunningham Associates recommended analyzing and upgrading seismic restraints for the two ground level tanks if needed to ensure an adequate water supply.

Pump Stations

The City of Milwaukie has a series of pump stations. These include seven (7) well head pumps, five (5) treatment pumps delivering flow from the stripping tower sites, seven (7) booster pumps feeding Zones 3 and 4, six (6) transfer pumps feeding from Zone 1 and the Stanley reservoir into Zone 2, and two (2) Clackamas River Water (CRW) intertie pumps.

Zone 1 receives water by well head pumps from Wells 2, 3, and 5. The well head pumps deliver water through the stripping towers into a clearwell for three (3) treatment pumps that deliver flow to the Zone 1 Concrete Reservoir.

The Zone 2 distribution system receives water from the well head pump from Well 8. Well 8 delivers flow directly into the Zone 2 distribution system. Wells 4 and 7 pumps deliver flow through stripping towers to the two (2) treatment pumps that deliver flow to Zone 2. In total there are four (4) transfer pumps, including two (2) manually operated diesel fire flow pumps at the Stanley pump station site that deliver flow from the Stanley reservoir into Zone 2 distribution. There are also two (2) pumps transferring flow from the concrete reservoir of Zone 1 into Zone 2. Zone 2 also receives flow from two (2) pumps intertied to CRW.

Zone 3 receives flow from four (4) distribution pumps drawing from the Stanley reservoir and Zone 4 receives flow from one (1) distribution pump and two (2) fire flow pumps drawing from Zone 1.

The treatment, booster, transfer and intertie pump information including design capacity and brake HP are listed below in Table 5-6. The well pump information is listed above under the Groundwater Wells portion of this section.

Other Facilities

Throughout the City of Milwaukie water distribution system there are a series of normally closed valves, check valves and pressure regulating valves that along with the pumping stations separate the city into four distinct pressure zones. The pressure regulating valves are 8-inch diameter and are capable of passing approximately 3,100 gpm continuously and 3,900 gpm intermittently.

Instrumentation and Controls

The City of Milwaukie has recently implemented a full supervisory control and data acquisition (SCADA) system to monitor and control much of the system's operations. This system allows the field personnel to quickly respond to pump trips, tank low level alarms, intruder alarms and many other conditions remotely from the field office or via cellular telephone. The monitoring system also allows the development of pump usage, tank level, and flowrate trends throughout the system. Currently there are only two pumps within the City's distribution system that are not capable of remote control. These two pumps are the diesel powered fire flow pumps located at the Stanley Transfer Pump Station (W6).

**TABLE 5-6
PUMP STATION POWER AND CAPACITY**

Pump Station ID	Number of Pumps	Horse Power (HP)	Design Capacity (each pump) (gpm)
Treatment Pumps 2,3,5	3	10	700
Treatment Pumps 4,7	2	75	900
Transfer Pumps Zone 1 to Zone 2	2	20	700
Transfer Pumps Stanley to Zone 2	2	50	1300
Transfer Pumps Stanley to Zone 2	2 (fire flow)	125	2250
Booster Pumps Stanley to Zone 3	2	20	250
Booster Pumps Stanley to Zone 3	2 (fire flow)	60	600
Booster Pump Zone 1 to Zone 4	1	15	300
Booster Pumps Zone 1 to Zone 4	2 (fire flow)	75	1750
CRW Intertie Pumps	2	10	700

Organization and Management

Staffing

The City's water system is operated by an Operations Supervisor, a Utility Specialist and five Utility Workers. The Water Operations Supervisor reports to the Public Works Director, who has responsibility for Engineering, Streets, Storm and Sewer and Water operations. Overall system responsibility extends from the Public Works Director to the Assistant City Manager, the City Manager and the City Council.

The water system is classified by the State as a Water Distribution System – Level 3. The State requires that such a system have a Level 3 operator certification. The current Operations Supervisor and Utility Specialist have this certification. These two individuals are also certified cross connection control inspectors. Two other members of the water operations staff have a Level 1 Water Distribution operator certification.

Standards, Codes and Plans

The City of Milwaukie follows standards and specifications for municipal water supply developed by the American Water Works Association (AWWA) and the Oregon chapter of the American Public Works Association. The AWWA Standards cover 116 products and procedures required for water system operation, and set the minimum requirements for the basic aspects of a drinking water system. The APWA has developed several sets of plans and specifications related to drinking water system operation that have been adopted by the Oregon chapter. The Oregon chapter also develops new standards and specifications.

The City maintains a call sheet for notification in the event of emergency, but does not have a written emergency response plan. The City does not have a formal water curtailment plan for use in times of water shortage. In the past, Milwaukie has relied on public information produced by the City of Portland to encourage water conservation in drought years. Milwaukie shares newspaper, radio and television service with Portland, so is able to effectively use these communications for its own citizens. As a groundwater system, Milwaukie is much less subject to weather-driven drought conditions than are its surface-water reliant neighbors. Water shutoffs are handled by the Operations Supervisor.

Budget

The total yearly operating budget for the water system in 1998-1999 was approximately \$800,000. Of this amount, approximately 40 percent was allocated to personnel costs for the water system employees; 12 percent to utility bills to run pump stations and other facilities; 10 percent for materials for meter installation, facility repair and vehicle upkeep; and 35 percent for accounting, engineering and administrative support to the water system. About \$530,000 is allocated to capital maintenance of existing facilities. The water department also maintains a Future Capital Reserve of about \$2.2 million to fund major projects.

Rates

The City currently bills its customers every other month, based on usage in hundreds of cubic feet, or ccf (1 ccf = 100 cubic feet = 748 gallons). The bi-monthly charge by water meter size is given in Table 5-4. A typical residential account has a ¾" meter. A commodity charge of \$1.35 per ccf is included in the bi-monthly bill. A typical residence will use 10 ccf per month, so a typical residential water bill will come to about \$16.50 per month. This is comparable to residential water rates for many other area water providers.

**TABLE 5-7
CURRENT WATER RATES**

Meter Size	Bi-Monthly Charge (\$)
¾"	5.95
1"	8.29
1 1/2"	13.38
2"	20.78
4"	72.78
6"	129.90
8"	650.00

for meters up to 6", an additional charge of \$1.35 per ccf
for 8" meters, above 320 ccf charged at \$1.16 per ccf

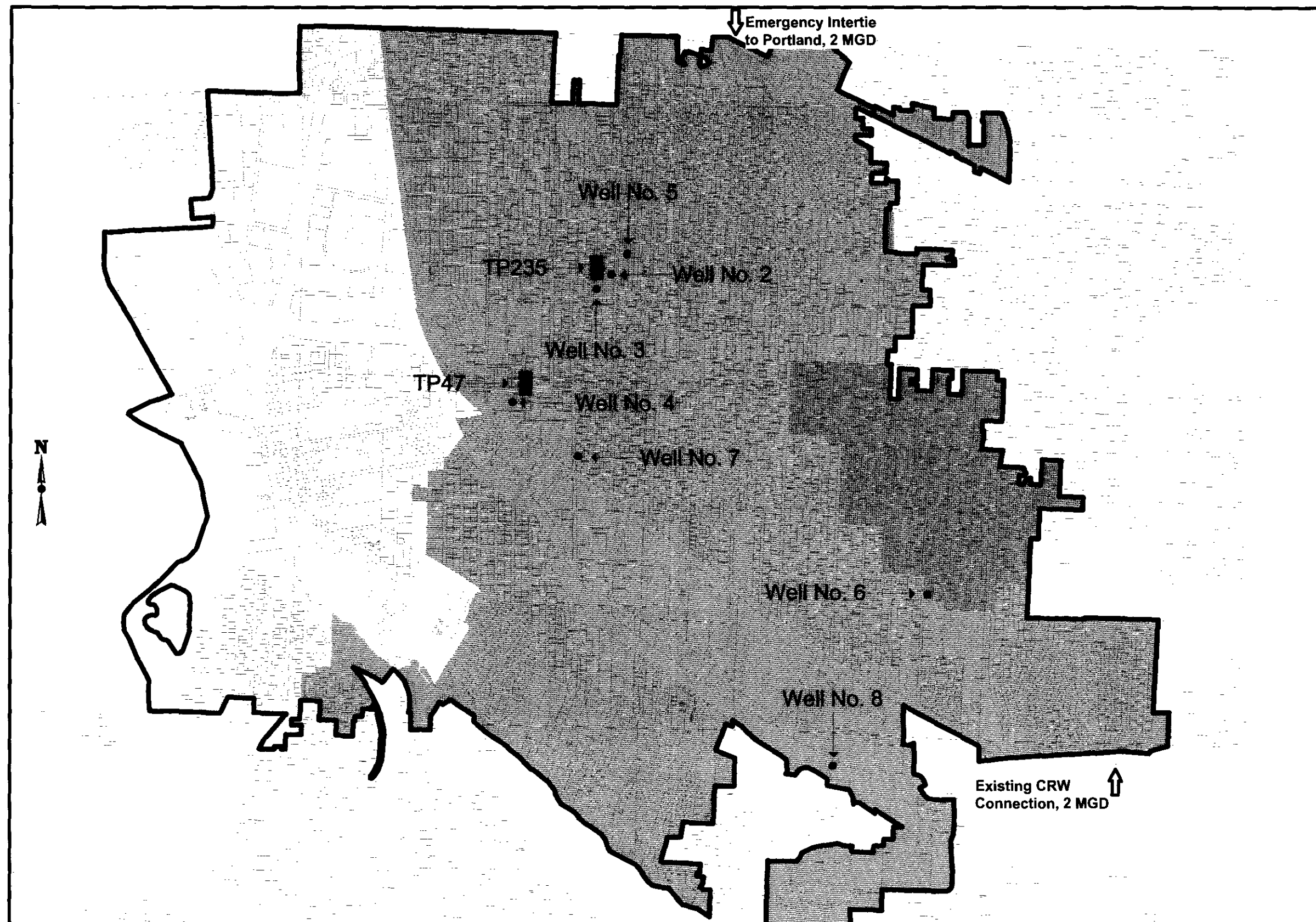
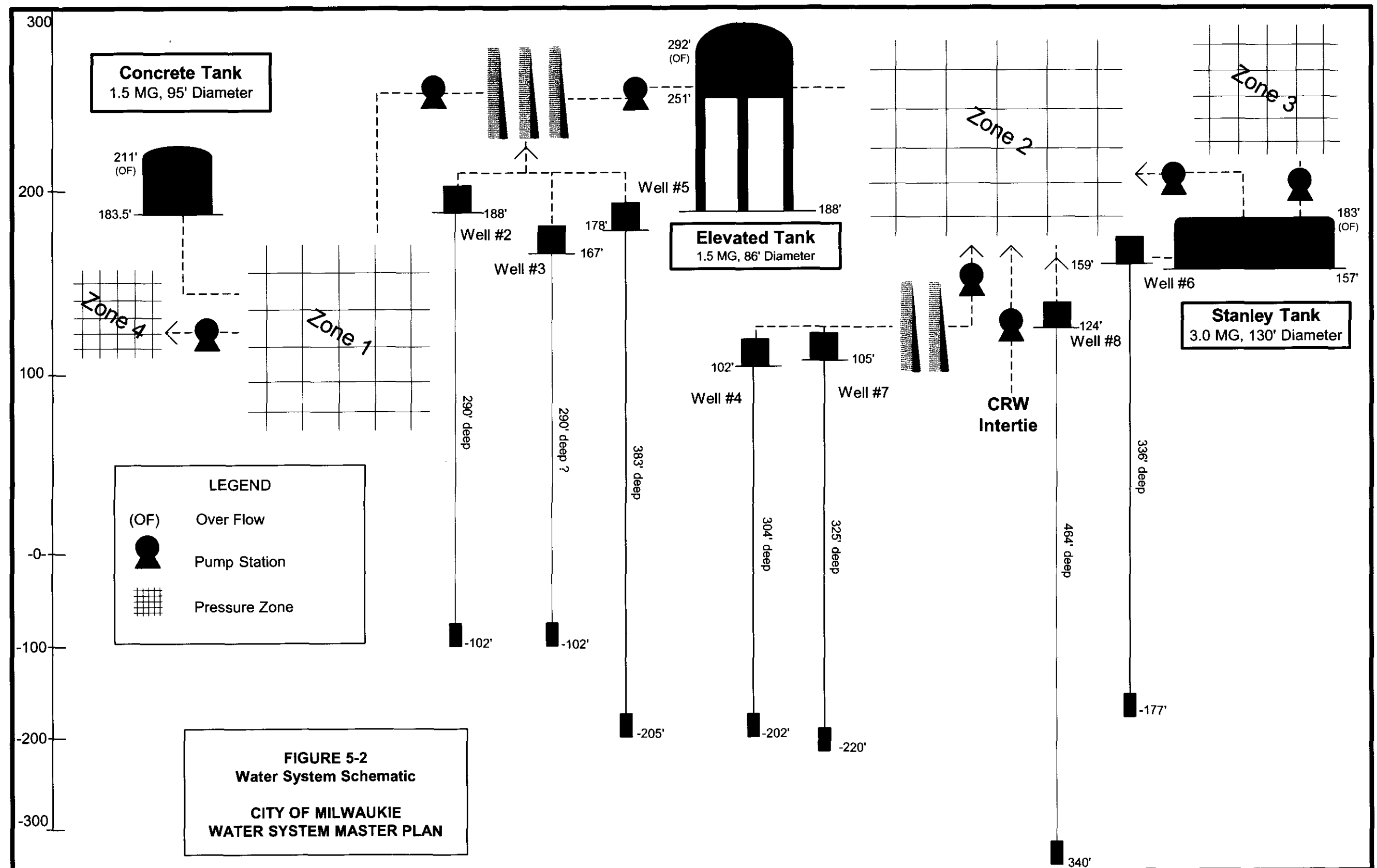


FIGURE 5-1
CITY OF MILWAUKIE GROUNDWATER WELLS

- Groundwater Well
- Stripping Tower
- Milwaukie City Boundary



SECTION 6- EVALUATION OF THE EXISTING SYSTEM

The City of Milwaukie's water system has been described in Section 5. The water system was evaluated in several ways in this Master Plan. These methodologies included field inspection of key facilities; a comparison of key facilities to the planning criteria; the development of a hydraulic model of the system; and a review of other issues and information. The results of these evaluations are given in this section. Capital improvements and other recommendations based on this evaluation are given in Sections 9 and 10.

Field Observation of Key Facilities

Elements of the City of Milwaukie's water system have been in service since the early 1900's. As with any water system, on-going operations and maintenance efforts are required to keep the system functioning. As time goes by, elements such as motors and control systems, valves and coatings can wear out or become obsolete, thus reducing the effectiveness of that segment of the system. In order to evaluate the current condition of some of the key components of the City's water system, qualitative, field observations were conducted on these key elements by Montgomery Watson personnel. Input was also obtained from Milwaukie water operations personnel who accompanied Montgomery Watson on the field visits. The purpose of the evaluation was to observe the general condition of the facilities and to provide recommendations for potential improvements that need to be performed as part of the Capital Improvement and Capital Maintenance Programs. The observation reflects conditions as noted at the time of the fieldwork, February, 2000. The observations are not intended to be a detailed evaluation, a safety inspection, or to serve any other purpose.

The results of the field observations are summarized below.

Pump Stations and Groundwater Wells

Each well and pumping facility was evaluated for level of maintenance, functionality, safety, and operating efficiencies. Overall the wells and pump stations are currently in good working order and appear to be operating efficiently. Also, the proper facilities and signage for safety are present.

Several observations were made. The pump motor for Well No. 6 was rebuilt in 1996 and the pump motor for Well No. 3 was rewound in 1995. It is recommended that each pump and motor be evaluated and rated against expected production and efficiency versus actual. This evaluation should identify any further pump / motor maintenance or needed replacement.

Well No. 7's pump motor currently vibrates outside normal operating conditions and should be evaluated and rebalanced to improve efficiency. Well No. 8's well shaft has been knocked

out of alignment and may be affecting pump station production efficiency from excessive suction headloss.

The fire flow pumps at the Stanley park site in the Well No. 6 transfer pump station as well as the fire flow pumps in the Lava Drive pump station should be reevaluated for possible engineered improvements. The pump station improvements should allow the fire flow pumps to operate without introducing significant pressure and/or surge conditions throughout their respective service areas, and should allow the fire flow pumps to operate in tandem with the existing service pumps.

Air Stripping Towers

The air stripping tower complexes located at well sites No. 2, 3, and 5 and at well sites No. 4 and 7 appear to be in good condition. Some of the external pipeline coatings on each stripping tower complex appear to be in need of stripping and replacement. Also the sight glasses on the control valves at each site have burst and need to be replaced. The sight glass replacement is strictly for operator convenience and esthetics and does not affect the valve operation.

Reservoirs

Each storage facility was evaluated for seismic restraint, condition of the coating system, structural integrity, access hatches, underdrain systems, and overflow drain systems.

All three of the City's reservoirs were evaluated in 1993 with respect to seismic stability. Recommendations for seismic restraint have been implemented, with the exception of the foundation improvements for the Elevated Steel Tank.

The coating system for each reservoir was in good condition. The "Concrete Reservoir" is scheduled to be repainted in FY2000 and the Elevated Steel Tank and Stanley Reservoir have been re-coated within the last 5 to 6 years. All tanks appeared to be structurally sound and capable of supporting current loading conditions. The "Concrete Tank" did have some exterior cracking that should be watched and repaired when necessary to protect post-tensioning wires from exposure and possible corrosion. For each reservoir, access hatches and ladder systems appear to be in good repair and meet current safety standards.

In 1995 the "Concrete Reservoir" was fitted with a Hypalon liner to decrease water loss from leakage. When the liner was installed the underdrain system was improved and now is capable of conveying the roof drainage to local stormwater facilities. The Elevated Steel Tank and the Stanley Reservoir are not outfitted with underdrain systems.

The overflow piping system for the "Concrete" and Stanley Reservoirs are piped directly into local stormwater drainage systems. The overflow system for the Elevated Steel Tank consists of a vertical exterior pipeline that discharges into abandoned Well No. 1. Part of this

overflow piping consists of a 3-inch PVC pipeline that does not appear to be restrained. This section of pipeline may fail during an overflow event.

Recommended Improvements

It is recommended that the following projects and evaluations are made to improve system reliability and efficiency:

- Evaluate booster pump stations and well head pumps for rated conditions and efficiency;
- Implement recommended seismic foundation restraints for the Elevated Tank;
- Re-engineer the Waverly Pump Station;
- Restrain Elevated Tank overflow pipeline. Re-route the overflow in order to cease discharge to groundwater Well No. 1.

Comparison of Key Facilities to Planning Criteria

The City of Milwaukie's water system was evaluated with respect to the planning and design criteria described in Section 4 of this Master Plan. The results of this evaluation are presented in the following sections.

A Comparison of Source to Planning Criteria

Peak Day Supply. The main source of supply for the City should be capable of providing the projected peak day demand. It should meet this demand with firm capacity - that is, with the largest component of the system out of service.

The City of Milwaukie has two primary sources of supply – its own groundwater, and purchased surface water from CRW. The existing contract between Milwaukie and CRW limits purchase of surface water on a routine basis to 0.5 mgd. For the purposes of this evaluation, 0.5 mgd is considered to be the capacity of Milwaukie's surface water source from CRW. The total capacity of Milwaukie's groundwater supply is 5.8 mgd. Therefore, the total available supply is 6.32 mgd. The largest single component of the groundwater system is Well 7, with a capacity of 1.4 mgd. If the system were operated with its largest component (Well 7) out of service, the total supply would equal 4.9 mgd.

Peak day demand in 1998 was 5.14 mgd. Therefore, the firm capacity of the existing supply is not capable of meeting peak day demand. Projected peak day demand at 2015 is 7.83 mgd. To meet projected peak day demands by the year 2015, the City should acquire an additional 3 mgd of firm source capacity. This would increase the City's firm capacity to 7.9 mgd.

The City has two basic alternatives to develop additional supply – to increase its groundwater production by the development of new wells, or to increase its purchase of

surface water from surrounding water providers. In the latter case, potential water providers include the City of Portland, Clackamas River Water and the Oak Lodge Water District. These supply options are evaluated in Section 7 – Future Water Supply Options.

Emergency Supply. It is recommended that the City maintain an emergency source of supply that is capable of providing the average day demand for the length of time that the primary source of supply is out of service, such period lasting up to a week. This emergency source could be provided through an intertie, storage, a secondary source, or other methods.

Current average day demand is approximately 2.5 mgd. By the year 2015, average day demand will increase to about 4 mgd. Therefore, the City's emergency supply should be able to deliver 4 mgd at buildout.

Milwaukie will not be able to provide emergency supply through storage. The City is already experiencing a storage deficiency, complicated by a lack of suitable new reservoir sites. The best option for the City is to provide emergency supply through interconnections with neighboring water providers. The City of Portland, CRW and OLWD are all viable options for emergency connections.

At the current time, the City maintains only one operational system interconnection, with CRW. The hydraulic capacity of this intertie is 2.0 mgd. Therefore, the existing emergency supply is not capable of meeting average day demand, with the entire groundwater system out of service. It should be noted that the assumption of a complete shutdown of the groundwater system is a very conservative scenario. However, a partial loss of groundwater did occur for three years in the late 1980's while the City addressed groundwater contamination.

The City is in the process of designing a new emergency intertie to Portland. The capacity of the intertie will be 2 mgd, and it will be brought on-line in late 2000. An abandoned intertie to the OLWD exists at Where Else Lane. Improvements would need to be made to this interconnection to create an additional source of emergency supply.

The City has multiple options for provision of emergency supply through interties with neighboring water providers. Options and recommendations for increasing emergency supply are discussed in detail in Section 7 of this Master Plan.

Comparison of Storage to Planning Criteria

Based on the planning criteria presented in Section 4 of this Master Plan, the required storage in each pressure zone will consist of 25% of projected peak day demand for equalization, plus the fire flow demand, plus one average day demand for emergency. These criteria are comparable to those used in the City's 1993 Water Source/Demand Study, and are typical of urban water systems.

Storage requirements have been evaluated by pressure zone, for each of the City's four zones. The projected equalization storage requirement, projected emergency storage

requirement and projected fire flow storage requirement have been totaled at the year 2015 to give storage requirements by zone.

Under the most conservative planning scenario, it is assumed that equalization, emergency and fire flow storage for the pressure zone must be located within that pressure zone, and be able to meet demand without pumping or pressure regulating across zones. This scenario assumes that each pressure zone is self-sustaining during all demand conditions. Fire flow requirements are for the largest fire in each zone. Commercial fires are assumed for Zones 1, 2 and 4, while only residential fire flows need to be met in Zone 3 due to its exclusively residential development. Under this approach, storage requirements are derived by adding all of the necessary components of demand for each zone, minus the existing storage in each zone. Table 6-1 illustrates storage requirements under this scenario at 2015. Table 6-2 illustrates storage deficits by zone under this approach at 2015. As can be seen from Table 6-2, a storage deficit exists in all four pressure zones. The total system-wide storage deficit becomes 11 million gallons at 2015.

**TABLE 6-1
STORAGE REQUIREMENTS - Conservative Approach**

Zone	Projected PDD (gpm)	Projected ADD (gpm)	Fire Flow (gpm)	Required Storage (mg)
Zone 1	1733.38	865.82	5000 @ 10 Hrs	4.87
Zone 2	3226.27	1611.52	5000 @ 10 Hrs	6.48
Zone 3	352.92	176.28	1000 @ 2 Hrs	0.50
Zone 4	124.93	62.40	3500 @ 10 Hrs	2.23

**TABLE 6-2
STORAGE REQUIREMENTS
CONSERVATIVE APPROACH**

ZONE	AVAILABLE STORAGE (MG)	SURPLUS/(DEFICIT) (MG)
1	1.5	(3.4)
2	1.5	(5.0)
3	0	(0.5)
4	0	(2.2)

This approach of completely independent zones may be desirable for water system master planning, but is unrealistic for a system such as the City of Milwaukie, which relies heavily on pumping and pressure reducing facilities to meet demands in all zones.

For an alternative storage analysis, it was assumed that all pressure zones are supplied by gravity, with the exception of pumped supply from the Stanley reservoir. The Stanley reservoir is normally emptied via two 1,300 gpm transfer pumps. However, this reservoir is also equipped with two diesel-powered, manually-operated fire flow pumps having a capacity of 5,100 gpm. The pumping capacity of 5,100 gpm from this reservoir is assumed to be operational under all conditions. Without this assumption, storage and pumping deficits become very large in all pressure zones.

Table 6-3 summarizes storage and pumping requirements at buildout under this alternative approach. The total storage deficit at buildout becomes about 3.5 MG.

**TABLE 6-3
STORAGE REQUIREMENTS UNDER RECOMMENDED SCENARIO
AT BUILDOUT (2015)**

ZONE	AVAILABLE STORAGE (MG)	SURPLUS/(DEFICIT) (MG)
1	4.22	(0.65)
2	4.00	(2.48)
3	0.00	(0.25)
4	0.00	(0.09)

Zone 1 Storage Requirements. Available storage is contributed by the 1.5 mg concrete tank in this zone, the elevated tank in Zone 2, and the Stanley reservoir. For stored water coming into Zone 1 from other zones, it is assumed that equalization and residential fire flow storage is reserved to meet the needs of those other zones, that is, only “surplus” stored water can be transferred into Zone 1. Also, it is assumed that only the Stanley tank fire flow pumps are working, and that all other storage must be transferred to Zone 1 by gravity flow. Table 6-4 summarizes the available storage components for this Zone. A total storage amount of 4.22 mg is available to meet the demands in Zone 1. As shown in Table 6-1, the required storage is 4.87 mg, therefore, a storage deficit of 0.65 mg will exist in this Zone at buildout conditions.

**TABLE 6-4
AVAILABLE STORAGE IN ZONE 1**

Storage Component	Total Storage Available (MG)	Amount Reserved for Other Zones (MG)	Net Storage Available (MG)	Notes
Concrete Tank (Zone 1)	1.5	0	1.5	all storage is available
Stanley Reservoir (Zones 2,3)	3	0.5	2.5	reserve 0.5 mg for FF+equalization in Zone 3
Elevated Tank (Zone 2)	1.5	1.28	0.22	reserve 1.28 mg for FF+equalization in Zone 2
TOTAL =	6	1.78	4.22	

Zone 2 Storage Requirements. In Zone 2, available storage comes from the elevated tank in that zone, plus “surplus” stored water from Stanley reservoir. In this zone, no water can be transferred by gravity from any other tank or source. Table 6-5 summarizes available storage for this Zone. A total amount of 4.0 mg is available to the Zone, while the projected storage need at buildout is 6.48 mg. Therefore, a storage need of 2.48 mg will exist in Milwaukie’s largest pressure zone by 2015.

**TABLE 6-5
AVAILABLE STORAGE IN ZONE 2**

Storage Component	Total Storage Available (MG)	Amount Reserved for Other Zones (MG)	Net Storage Available (MG)	Notes
Elevated Tank (Zone 2)	1.5	0	1.5	all storage is available
Stanley Reservoir (Zones 2,3)	3	0.5	2.5	reserve 0.5 mg for FF+equalization in Zone 3
Concrete Tank (Zone 1)	0	0	0	cannot transfer flow by gravity to Zone 2
TOTAL =	4.5	0.5	4.0	

Zones 3 and 4 Storage Requirements. These zones are unique in that there is no available storage in these zones, and all demands are met by pumping. Therefore, these zones will always be deficient in storage. City of Milwaukie staff have indicated that no sites exist at the appropriate elevation to serve these areas by gravity. For the purposes of

this analysis, it is assumed that peak hourly demand plus fire flow must be supplied to these zones by pumping. In both cases, the ultimate capacity of the pump station is adequate to meet required flows, but not the firm pumping capacity. Pumping capacities are discussed further in the following section.

The approach to evaluating storage deficits in pressure zones in this Master Plan assumes that existing facilities within the City will be adequate to deliver required flows in Zones 1 and 2. In Zone 2, the 5,100 gpm Stanley fire flow pumps are assumed to be capable of meeting instantaneous demands. In Zone 1, the Stanley pumps plus the hydraulic capacity of the PRVs into Zone 1 of approximately 9,000 gpm are assumed to be capable of meeting instantaneous demands anywhere within the zone.

Under current demand conditions, storage requirements are smaller than for buildout conditions. Zone 1 does not have a deficit under existing demand conditions, although a deficit of about 1.5 mg exists in Zone 2 under current conditions. Zones 3 and 4 are deficient in storage because of their reliance on pumping for supply. Emergency storage deficits in these zones are 0.17 mg in Zone 3 and 0.05 mg for Zone 4. Pumping facilities are adequate to deliver required flows to these zones under current conditions. Table 6-6 summarizes storage requirements under current conditions.

**TABLE 6-6
STORAGE REQUIREMENTS
EXISTING CONDITIONS**

ZONE	AVAILABLE STORAGE (MG)	SURPLUS/(DEFICIT) (MG)
1	4.22	0.16
2	4.00	(1.47)
3	0.00	(0.17)
4	0.00	(0.05)

In summary, storage deficits exist in three of the City's four pressure zones under current conditions. By 2015, storage deficits will exist in all pressure zones. These deficits are most significant in pressure zones 1 and 2. For zones 3 and 4, a lack of tank sites at appropriate elevation means that these smaller zones will continue to rely on pumping for provision of peak hour and fire flow demands. These smaller zones will continue to be deficient in emergency storage that should be supplied by gravity flow.

Storage options

It is assumed that pressure zones 3 and 4 will continue to be served by pumped supply. Additional storage is needed in zones 1 and 2. The ideal scenario would be to locate gravity storage at an elevation which is suitable for service to zones 1 and 2. The total storage increment to serve both zones at buildout is approximately 3.1 MG.

Several alternatives exist for the provision of additional storage. These options are:

- **Joint storage with CRW.** CRW maintains existing storage to the east of the City of Milwaukie, at the Otty Road reservoir site. The Otty Road site includes three reservoirs with a current capacity of 7.3 MG. This site is shown in Figure 6-1, and is marked as site number 11 on the figure. The overflow elevations of these tanks are at about 383 feet. This provides adequate driving head to deliver water to Milwaukie's reservoirs which have overflow elevations of 292 feet and below. Major transmission lines are already in place to deliver water to Milwaukie's city limits. CRW is currently pursuing an expansion of the reservoir site through acquisition of adjacent property. To meet current and near-term demands, the City could pursue the purchase of surplus storage capacity from CRW. To meet buildout storage needs, the possibility exists to jointly construct new storage with CRW on the expanded Otty Road site.

A major advantage of this storage option is that it is integrated with other transmission improvements which are recommended as part of this Master Plan. Water from the Otty Road reservoir would be delivered to Milwaukie at a proposed new CRW intertie location at SE Overland St. and Linwood Avenue. The second CRW intertie is a recommended component of this Master Plan in order to increase base and emergency supply. The intertie is discussed in more detail in Section 7 – Future Water Supply Options. Recommended improvements to the City's system as part of the intertie project include approximately \$300K of pipeline upsizing along SE Front St. and along Stanley Avenue. These intertie improvements would also serve to deliver stored water from the Otty Road reservoir to the City's system. Without pumping or regulating, and without any system modifications on the CRW side, the proposed intertie can deliver approximately 950 gpm, or 1.4 mgd of supply to Milwaukie. In order to increase delivery flows from storage at Otty Road during fire events, the new intertie could be equipped with manually-operated fire flow pumps. Required pumped flows during a fire are about 5,800 gpm in order to provide fire flow and equalization needs.

CRW also owns property for a potential future reservoir to the south of the City, at Center Street. This is also a relatively high-elevation site, marked on Figure 6-1 as site number 3, and would be compatible with Milwaukie's existing transmission system. No storage currently exists on the site, however.

- **Pursue acquisition of high elevation sites inside the Urban Growth Boundary.** A detailed site evaluation is beyond the scope of this Master Plan. However, a preliminary evaluation of this option was conducted using available topographic information. A brief follow-up site visit was conducted to determine if there were any major variances which were at odds with the map review. Sites within the Urban Growth Boundary

(UGB) having a ground elevation of 250 to 300 feet were searched. No sites of the appropriate elevation were found within the UGB. Figure 6-1 indicates locations for potential new storage. One site was found at the appropriate elevation, outside the Milwaukie City limits and just outside the UGB, within the OLWD service area (site #10). Areas immediately to the north of the city boundary, within the City of Portland were examined also, but could not provide the necessary elevation.

The potential OLWD site is on public property, at the View Acres elementary school. This site offers significant advantages, in that it too is integrated with other recommended system improvements. The potential reservoir site connects readily to proposed intertie improvement project recommended as part of this Master Plan. Proposed improvements include installation of a new 12-inch transmission line from the OLWD to Where Else Lane. This intertie is recommended in order to improve emergency supply for the City. The intertie project is discussed in more detail in Section 7 – Future Water Supply Options. The reservoir site offers a suitable ground elevation of 320 feet and can deliver approximately 3 mgd to Milwaukie, at a flow rate of about 2,000 gpm.

The major disadvantage of this site is its location outside the UGB, and current use as a school site. This will increase the difficulty of permitting a new reservoir.

- **Pursue acquisition of low elevation sites.** Ground area may be available for increased storage at the Stanley reservoir site, although space is constrained here. Property to the east of the Stanley reservoir, outside the city limits was evaluated. This farmland property (indicated as site #6 in Figure 6-1) has been considered by the City for some time as a potential reservoir site. However, this property and other potential sites are at low elevations which would present engineering and operational challenges.

The ground elevation at the potential farmland property is 180 feet. It is about the same as the ground elevation at Stanley tank, and would require pumping. Operating pumps would be sized to empty the reservoir at flows of 800 gpm. During fire events, manually-operated fire flow pumps could be installed to provide the required 5,800 gpm for fire flow and equalization needs.

The primary disadvantage of this option is its reliance on pumped storage. The low elevation of the tank may also result in low turnover and poor water quality. The availability of the site and the owner's willingness to sell is also a question.

Cost comparisons of the reservoir options discussed above are presented in Table 6-7. Costs are based on assumed storage of 3.1 MG. Costs are based on new reservoir construction at all three sites. It should be noted that surplus storage capacity may be available at the Otty Road site which could decrease and/or delay these costs significantly.

**TABLE 6-7
STORAGE OPTIONS**

Option	Storage Cost (in thousands \$)			
	storage cost	pumping cost	transmission cost	Total cost
Otty Rd. Reservoir - CRW	1,339	192	313	1,844
Center St. Reservoir - CRW	1,339	448	598	2,385
High site - OLWD	1,339	222	751	2,312
Stanley tank area	1,339	481	288	2,108

Pumping costs include dual operating pumps and fire flow pumps at the Stanley Tank area site, and dual fire flow pumps at the Otty Road and OLWD sites. In total, the Otty Road reservoir site is the most cost-effective, even assuming that 3.1 MG of new storage will be constructed at the site, which is a conservative assumption.

A comparative cost analysis favors the CRW Otty Road storage option over the other alternatives. The cost comparison should also consider the efficiencies of integration with other recommended system improvements, as was discussed above. For the CRW (both Center Street and Otty Road) and OLWD storage options, new storage would be constructed as part of recommended intertie improvements. Therefore, the bulk of the transmission costs associated with these options can be assumed to be sunk costs because the transmission improvements would occur regardless of the reservoir construction. Considered from this perspective, the total CRW storage cost for Otty Road becomes \$1.5 M, the CRW- Center Street option becomes \$1.8 M, the OLWD storage option becomes \$ 1.5 M and the Stanley option remains \$ 2.1 M. Under this scenario, the CRW Otty Road and OLWD storage options are comparable. The CRW Otty Road storage option is recommended for two reasons: 1) the OLWD site is outside the UGB, which may affect project cost and increases the complexity of the siting process; and 2) actual storage costs for the CRW option will be lower than shown here, as Milwaukie can use current surplus available storage at Otty Road. The cost comparison above assumes the construction of new storage at the site.

It is recommended that Milwaukie pursue opportunities for joint storage with CRW at Otty Road. If this proves to be infeasible, Milwaukie should evaluate locating high-elevation storage outside the UGB. As a final option, lower elevation storage within the UGB should be pursued.

Comparison of Pumping Facilities to Planning Criteria

The following planning criteria were used to identify deficiencies in pump stations:

- Sized for firm capacity equal to peak day demand;
- Two sources of power supply, or one main source and standby/emergency power; and
- Secondary source has enough capacity to pump average day demand or fire flow, whichever is greater.

A summary of the pumping facilities for the City of Milwaukie is presented in Table 6-8. The nominal firm capacity indicated in the Table is the rated capacity of the pump station with the largest pump out of service. The actual firm capacity will be different from the nominal because pumps will be operated at different points on their operating curve. The Table also includes the nominal ultimate capacity of each pump station.

Table 6-9 summarizes the ability of existing pumping facilities to meet projected peak day demands at buildout. Pumping facilities are adequate to meet peak day demands in zones 1, 2 and 3 with the firm capacity of the pump station. Zone 4 is a special case. At the Lava Drive pump station, a single 300 gpm operating pump is in place, together with two 1750 gpm fire flow pumps. During normal conditions, the single operating pump provides flow. There is no secondary operating pump, therefore the firm capacity of this station is zero. It is recommended that a second operating pump having a design capacity of 300 gpm be installed at this pump station. The design of the existing pump station is extremely constrained, and it is unlikely that another pump can be placed in the vault. The City should evaluate options for increasing the firm capacity of this station, either through redesign of the existing facility or through construction of a new station, salvaging the existing pumps.

Table 6-8
Summary of Milwaukie Pumping Facilities

Zone	No. of Pumps/PRVs	Pump Station	Firm Capacity (gpm)	Ultimate Capacity (gpm)
------	-------------------	--------------	---------------------	-------------------------

Zone 1	3	TP235	1,400	2,100
	4	PRVs	9,000	9,000
		Total	10,400	11,100
Zone 2	2	CRW Intertie	700	1,400
	2	W2 Transfer Pumps	700	1,400
	4	W6 Transfer Pumps*	1300/5100	2600/7600
	1	W8 Well Pump	0	750
	2	TP47 Pumps	900	1,800
		Total	7,400	12,950
Zone 3	4	W6 Booster Pumps	1,100	1,700
Zone 4	3	Lava Drive PS**	0/1750	300/3500

* Also shows 2 x 2500 gpm fire flow Pumps

** Also shows 2 1,750 gpm fire flow pumps

Table 6-9
Pumping System Analysis

Zone	Projected PDD (gpm)	Firm Capacity (gpm)	Surplus / (Deficit) (gpm)
Zone 1	1,733	10,400	8,667
Zone 2	3,226	7,400	4,174
Zone 3	353	1,100	747
Zone 4	125	0	-125

The pumping facilities that serve Zones 3 and 4 deserve additional attention because they are required to meet all the demands of these zones, due to a lack of storage within the zones. For the purposes of this Master Plan, it is assumed that the pumping facilities must be capable of supplying the peak hourly demand plus fire flow demand. Table 6-9 summarizes the capacity of the pump stations relative to this requirement under existing and buildout conditions. In both cases, this criteria can be met with the ultimate capacity of the pump station, but not with the firm capacity.

All of Milwaukie's pump stations are equipped with backup power, and meet this criterion.

Comparison of Pipelines to Planning Criteria

Approximately 15% of the City's distribution system consists of pipeline less than 6 inches in diameter. These pipelines do not meet the planning criteria defined in Section 4 of a minimum of 6 inches for pipelines. It is recommended that all of these pipelines be replaced over time with new pipeline of at least 6 inches in diameter to provide adequate fire flows. Approximately 17 miles of small diameter pipeline would be replaced as part of an ongoing Capital Maintenance Program.

Fire hydrants should only be installed on pipeline of 6-inch diameter or larger. Pipelines that are equipped with fire hydrants should be part of a looped system in order to deliver adequate fire flow. It is estimated that about 5 percent of the City's 6-inch pipeline may not meet the criterion for looped flow. The hydraulic modeling conducted as part of this Master Plan did not evaluate fire flow on each of the 2,250 pipeline segments of the distribution system, therefore specific pipeline reaches have not been identified as deficient with respect to this criterion in the CIP.

Summary and Conclusions

Some deficiencies exist in the system under current and projected conditions.

- ❑ The firm capacity of the City's groundwater/surface water supply is not capable of meeting existing peak daily demand. The existing emergency supply is not capable of meeting existing average day demand, with the groundwater system out of operation.
- ❑ Significant storage deficiencies exist in pressure Zones 1 and 2 under buildout conditions. Emergency storage is lacking in Zones 3 and 4 due to an absence of gravity storage.
- ❑ Pumping facilities are adequate to meet current and projected peak day demands at firm capacity, with the exception of Zone 4. The Zone 4 booster pump station should be upgraded to increase firm capacity. The ultimate pumping capacity of existing facilities to supply peak hour plus fire flow demands in Zones 3 and 4 is adequate at buildout conditions.
- ❑ Pipelines less than 6 inches in diameter need to be replaced with 6-inch pipeline to deliver fire flows and maintain a minimum system pressure of 20 psi. Approximately 17 miles of small diameter pipeline should be replaced over time as part of an ongoing Capital Maintenance Program. Pipeline of 6-inch in diameter and above that are equipped with fire hydrants should be part of a looped system, in order to deliver adequate fire flow.

These findings form the basis of the capital improvement recommendations presented in Section 9 of this Master Plan. The results of the hydraulic model evaluation provide the basis for additional capital improvement projects, based on current and projected hydraulic deficiencies. The hydraulic modeling results are discussed below.

Hydraulic Model Evaluation

Model Methodology

The steady state hydraulic model developed for this master plan utilizes the H₂ONET 3.0 software. This software is currently one of the leading commercially available hydraulic analysis tools and is supported by MW-Soft, Inc. The H₂ONET model developed for this master plan is set up to analyze the system at one point in time with known boundary conditions (e.g. reservoir levels, pump status, PRV settings). This model setup is used for planning and allows multiple scenarios to be reviewed and results checked against established criteria. The following is an explanation of the modeling software architecture.

The H₂ONET model is based on the Hybrid (or Gradient) method for network analysis. This method has two very attractive features. First, it combines the good convergence properties of Newton's method, the better conditioning properties and starting values of the loop formulation, and the inherent scarcity of the nodal formulation. Second, the system of linear algebraic equations to be solved at each iteration is symmetric and positive definite. This allows for highly efficient matrix routines to be used for their solution. The system of equations to be solved is of dimension equal to the number of nodes. The model can accommodate any type of hydraulic device and computations may be carried out using both English and SI units. The model also implements advanced computational routines enabling the program to exhibit higher execution speed.

The H₂ONET software was programmed using the open architecture concept and consists of three modules, the core module of which is a relational database. The relational database stores and manages the network modeling data and allows the software to maintain a series of unique linkages between the modeling database and the other two modules: the graphical network map in AutoCAD and the network simulator. Through a specialized graphical interface developed for AutoCAD, the user populates the modeling database, runs the model, and views, queries, and displays modeling results. The relational database acts as the central storage location for all network modeling data. From this database, inputs to the hydraulic model are generated and model results are associated for display on the network map. The map acts as a graphical interface to these relational data. By combining all engineering applications into one central database, all system maps and facility data can be continuously and accurately maintained and updated.

H₂ONET provides great flexibility in file sharing capabilities with various popular GIS software applications. The user can automatically import/export data files (both graphics and attributes) using the GENERATE (e.g., Arc/Info) and SHAPEFILE (e.g., ArcView) GIS formats. With complete CSV (comma-delimited text) data transferring capabilities, the user is able to directly share data with any other GIS software and standard database.

Model Development

For the City of Milwaukie, the existing and future systems were hydraulically modeled in order to evaluate system capacity and develop recommended improvements. The distribution system was digitized using Metro RLIS base maps to identify tax lots, zoning, city limits, and streets. The City of Milwaukie provided SHAPE files converted from their GIS basemaps. The SHAPE files included topography, vacant land locations, water node locations, and water pipeline alignments. The digitized distribution system was then reviewed by the City of Milwaukie to check for connectivity and locate closed valves. Working with the City of Milwaukie, several pipeline alignments and characteristics were changed from the existing information and new distribution pipelines were added to the model. A total of approximately 108 miles of pipeline are included in the model. Well logs, historical demand data, pump data, reservoir data, and a field check of pressure reducing valve settings were also provided by the City of Milwaukie.

A complete hydraulic model was constructed with all the major facilities in the system, including pipes, pumps, reservoirs, sources, tanks, and valves. Once the system was laid out and all pertinent parameters were verified (such as pump curves, nodal elevations, demand allocations), the system was calibrated.

The H₂ONET software uses databases to store input and output for each facility. The input databases for nodes (locations where two pieces of pipeline in the model intersect) included elevation, demand, and pressure zone. Pipeline input databases included diameter, length, and roughness coefficient (based on material and age of pipeline). Storage tank databases included elevations and storage volumes; pump stations included pump curves; and PRVs included pressure settings and valve diameter sizes.

Demand Allocation

Demand projections were based on population, as presented in Section 3. The projections were developed using four planning horizons: existing and for the years 2005, 2010, and 2015. Demands were developed based on land use and zoning. The ten largest users in the city were also identified.

Model Calibration

The initial model runs were made to determine if the model behaved as anticipated. These initial model runs provided a check for model stability. As part of this process, SCADA data was used to check pump station operation, reservoir status, demand allocations, and source contributions.

After the initial check for model stability, the calibration of a hydraulic model is relatively straightforward. The calibration of the model was a “steady-state” calibration. That is, the model was calibrated assuming that flows, reservoir levels, pumping rates, and other system conditions are occurring at a constant rate, or steady-state condition. While this assumption is adequate for planning purposes and determining the overall condition of the system for Capital Improvement Program development, it is not adequate to use the model as an

ongoing operational tool. A dynamic calibration called an “extended period simulation” (EPS), should be conducted in the future if the City wishes to use the hydraulic model to assist in optimizing operations. In an EPS model simulation, the fluctuations of reservoir levels, pumping rates, and other system variables, which occur over the course of a day, are simulated. The City’s SCADA system allows for the collection of the data needed to develop an EPS model.

The hydraulic model calibration consisted of making a series of hydrant flow tests during peak season demands and recording all pertinent system parameters during the testing period. This allowed the analyst to set the system boundary conditions in the model to an in-situ condition and use the pressure and flow parameters from the hydrant tests to provide a mark for system calibration. The water distribution system was calibrated (within 10% of field test) by adjusting pipeline roughness coefficients. The pump operating curves, pressure control settings, and location and setting of isolation valves were also checked and verified during the calibration effort.

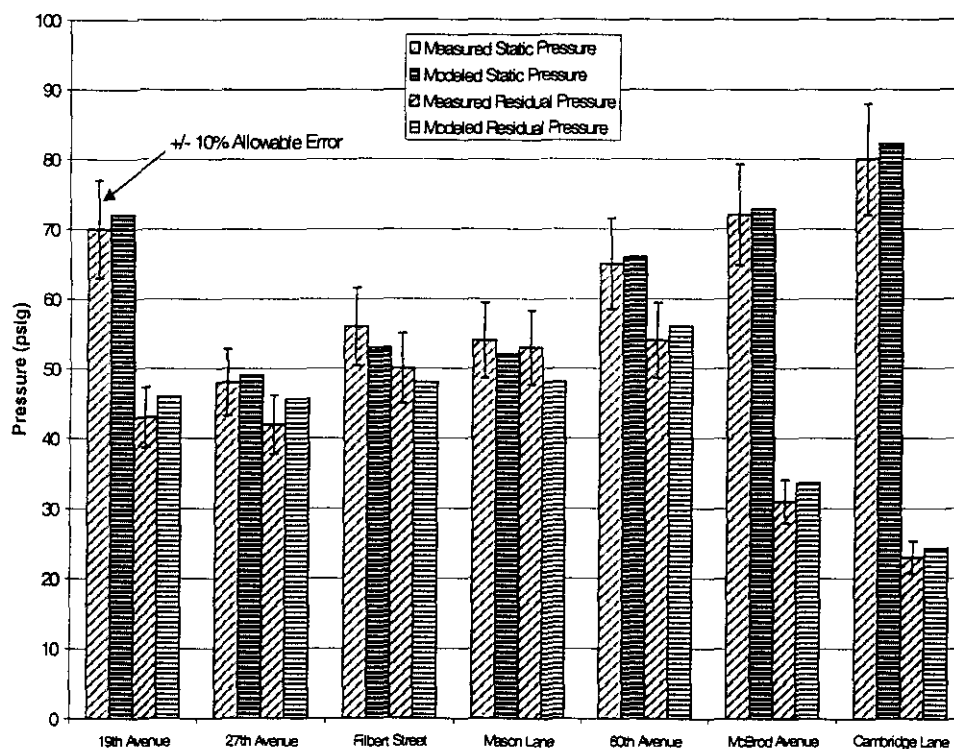
The most common parameter, which prevents the calibration of the hydraulic model to real time data, is the setting of the isolation valves. Throughout a system network, there may be numerous valves (i.e. isolation valves) that are unaccounted for and/or misrepresented. The setting of a valve may be represented as fully opened when actually it is partially or fully closed. A partially closed valve can be very difficult to identify and a valve may result in extreme hydraulic variations in the network that is not accounted for in the model.

To adequately calibrate the water system model, a complete flow testing was conducted in each pressure zone. The flow testing performed included 7 locations throughout the service area on September 9, 1999. At each location, a primary hydrant flow test was performed and a static and residual pressure was measured at two secondary hydrants. A hydrant flow test was made at as many locations as feasible to adequately describe the hydraulic network. A partially closed valve was identified in the McBrod area during calibration. Further investigation is needed to verify the exact location of the partially closed valve. Table 6-10 and Figure 6-2 summarize calibration results for the flow tests.

Table 6-10
Calibration Results Data

Location	Static Pressure Observed	Static Pressure Modeled	% Error	Residual Pressure Observed	Residual Pressure Modeled	% Error
19 th Avenue	70.0	72.0	-2.8	43.0	46.0	-7.0
27 th Avenue	48.0	49.0	-2.1	42.0	45.6	-8.6
Filbert Street	56.0	53.0	5.4	50.0	48.0	4.0
Mason Lane	54.0	52.0	3.7	53.0	48.0	9.4
60 th Avenue	65.0	66.0	-1.5	54.0	56.0	-3.7
McBrod Avenue	72.0	72.9	-1.2	31.0	33.7	-8.7
Cambridge Lane	80.0	82.2	-2.8	23.0	24.3	-5.6

Figure 6-2
Hydraulic Model Calibration Results



Pipeline Deficiencies Analysis

Each of the planning horizons were evaluated using the planning criteria presented in Section 4. Pump stations and storage tanks have defined design capacities, as presented in Section 5. Pipelines, however, function as part of a larger network and must be evaluated through modeling for various demand scenarios. Two demand scenarios were investigated:

- (1) peak hour demands, and
- (2) peak day demands plus fire flows.

For the second scenario, one fire flow at a time was applied to each of the four pressure zones using a residential fire flow of 1,000 gpm during a projected peak day demand condition. The system was also evaluated for non-residential fires modeled in each of the four zones using 5,000 gpm for industrial and commercial fires and 3,500 gpm for multi-family (i.e. apartment complexes) fires. Where industrial/commercial or multi-family fire flows are established, the fire flow modeling occurred at the location of the specific industrial, commercial, or multi-family facility which would generate the high fire flow. Figure 6-3 shows the location of each node with an applied fire demand.

The following planning criteria were used to identify deficiencies in pipelines:

Peak Hour Demand Scenarios

- Transmission pipelines (12-inch diameter and larger) with velocities greater than 5 fps on peak day demands;
- Distribution pipelines with velocities greater than 10 fps and headlosses greater than 10 ft per 1000 ft on peak hour demands; and
- Pressures less than 40 psi or greater than 100 psi.

Maximum Day Demand Plus Fire Flow Scenarios

- Pressures less than 20 psi.

The system-wide peak day demand used in the existing analysis was 5.1 mgd as defined in Section 3. The system wide peak hour demand, which corresponds to a flow of twice the peak day demand, was 10.2 mgd. The future demand projections were applied using a multiplier derived from the existing and future demands defined in Section 3. All existing pumps, storage facilities, and operational settings were modeled to evaluate the existing system.

Capital Improvement Development

The analysis of the system and recommended improvements to correct deficiencies were developed in a step-by-step process. First, the existing system was evaluated for deficiencies under both the peak hour demand and the peak day demand plus fire flow scenarios. The improvements needed to remedy these existing deficiencies were then incorporated into the model. Improvements may include valve setting adjustments and new or parallel pipelines. The improved system became the basis for the next analysis of future planning horizons. This approach prevents redundant modeling of deficiencies of the existing system.

The demand projections were then applied in 5-year increments starting with 2005, as improved for existing deficiencies. Again, both the peak hour demand and the peak day demand plus fire flow demand scenarios were evaluated. Where deficiencies existed for the 2005 projection, improvements were identified by two methods. First, an attempt was made to expand an improvement that was already identified as needed to correct an existing system deficiency. Where this was not feasible, either hydraulically or economically, new improvements were identified to relieve 2005 projection deficiencies. The system as improved to meet the 2005 demand projections became the basis for the repeated analysis of the 2010 demand projection. The system as improved for the 2010 demand projection subsequently became the basis for the 2015 demand projection analysis and so on.

Identified System Deficiencies

Model analyses showed that existing-system, peak hour deficiencies are limited to three pipeline segments, having a total length of 1,547 lineal feet. All of the existing pipeline segments are 4-inch diameter pipes that cannot deliver the existing peak hour demands. Capital improvements to correct these deficiencies were identified. Analysis of the system for the existing peak day demand plus fire flow demand scenario identified only two pipeline deficiencies, both in Pressure Zone 1, at the far northwest corner of the City's system. A total of \$337,355 of improvements is required to correct existing pipeline deficiencies.

Analysis of the 2005, 2010, and 2015 demands showed only six relatively minor pipeline deficiencies, all in the vicinity of the Concrete and Elevated Tanks. All of these pipelines will need to be upsized to meet projected peak hourly demands. The pipeline capital improvements that were identified, the existing and future deficiency that was relieved by the improvement, and the costs for each pipeline capital improvement are presented in Section 9. In addition, multiple pipeline connection projects were identified to improve future peak hour flows. Again, connectivity improvements were identified in the vicinity of the two reservoirs. A total of \$371,372 in future system improvements is recommended.

The modeling identified the need for an estimated \$710,000 in pipeline improvements between now and 2015. These improvements are shown in Figure 6-4.

With few exceptions, improvements were assumed to replace the existing pipeline. Mains along Clatsop St. and McLoughlin Blvd. in Pressure Zone 1 were assumed to parallel relatively new existing pipelines in good condition that can remain in the ground. New pipeline near Johnson Creek Blvd. and Front St. in Pressure Zone 2 is an operational improvement to create more loops in the system. In all other cases any existing pipeline was replaced with a new pipeline.

Low pressures were identified near pressure reducing valves. Resetting of the pressure reducing valves to a higher pressure may improve the pressure in these areas. Low pressures were also identified near storage reservoirs where elevations of the distribution system

service are so close to the storage tank that pressures cannot meet the planning criteria. For these locations, no capital improvements were identified as being helpful in alleviating these conditions. If customers are not experiencing problems, then no action is warranted. If in the future some customers do experience problems, a case-by-case review of the options should be made. Rezoning, booster pumps, resetting of the pressure reducing valves, and other options may be available if the problem warrants such action.

Review of Other Information and Issues

Service Replacement

An ongoing program of service renewal should be provided for in the Capital Maintenance Program. It is assumed that water services will be replaced on a 75-year cycle. With approximately 7,000 services in the system, this would require the replacement of 90 services a year.

Rate Structure

The City already uses a cost-of-service method that incorporates a service charge for customer and meter-related costs, and a commodity charge for all amounts of water. The City may wish to consider conservation-oriented inclining block rate structures for the commodity charge. Many communities in the metro area have gone to this rate structure, particularly during the summer months in order to reduce peak day demands. Under this type of rate structure, those who use relatively high amounts of water pay a larger share of the total cost of providing water. The City may also wish to review its charges and procedures for recovering costs of unmetered, authorized water uses such as construction water.

Conservation Programs

The City participates in various conservation activities with other water providers in the area. The City receives particular benefit from the City of Portland's extensive conservation outreach activities, as Milwaukie shares newspaper, television and radio coverage with Portland. Portland is an active member of the Columbia-Willamette Conservation Coalition and sponsors many outreach activities which affect water use patterns in the Milwaukie area. These activities include conservation workshops, newspaper ads, radio and television spots and school presentations. The City of Milwaukie also provides public information on wise water use through its own publications and mailers to customers.

In addition to public education efforts, the City has been aggressively pursuing a reduction in water loss through leak detection and main replacement and old distribution system components such as meters and valves.

Staffing Level

A detailed evaluation of the staffing needs for the water system is not within the Scope of Work of this Master Plan. However, some general comments can be provided.

The City's organizational structure is typical of many cities the size of Milwaukie. Staff includes a water crew under an operations supervisor, with engineering support provided by an engineering branch of a Public Works Department. It is a means of efficiently using limited personnel resources to satisfy a number of municipal operating needs.

Current staffing levels appear to be able to adequately maintain and operate the existing facilities and system. However, staff may have inadequate time to conduct work which goes beyond the routine maintenance and operation of the system. Areas such as responding to upcoming drinking water regulations and maintaining a better compliance record for existing monitoring requirements, better record keeping of unmetered water uses, and improvements to the cross connection control program are unlikely to be implemented with current staffing levels. The City should review its staffing levels and consider whether staff increases are needed in order to implement the recommendations of this Master Plan.

 Land Owned by Milwaukee
 Vacant Land
 Milwaukee UGB
 Milwaukee Boundary
 Possible Reservoir Site
 Elevation at Site
 xxx
 Contours (>250')
 Contours (<250')

1

Possible Reservoir Locations

Figure 6-1



City of Milwaukie Water System Improvement Plan

LEGEND

- Existing Conveyance System
- Residential Fireflow (1000 gpm)
- Multi-Family Fireflow (3500 gpm)
- Industrial/Commercial Fireflow (5000 gpm)
- Pressure Zone 1
- Pressure Zone 2
- Pressure Zone 3
- Pressure Zone 4

SCALE 1" = 1600'

IF THIS BAR DOES
NOT MEASURE 1"
THEN DRAWING IS
NOT TO SCALE

Fire Flow Locations

Figure 6-3

SECTION 7 – FUTURE SOURCE OF SUPPLY OPTIONS

This Master Plan has identified planning and design criteria for the City's water supply system. These criteria were presented and discussed in Section 4. The planning and design criteria serve as standards for an evaluation of the existing system, and also provide a means to plan for future capital improvement and capital maintenance projects.

One important set of criteria relate to the adequacy of the City's source of supply to meet existing and future demands. An evaluation of the City's current groundwater supply reveals that Milwaukie is in immediate need of additional supply, in order to reliably meet existing peak day demands. This need is projected to grow as population increases over the next fifteen years. This section discusses the City's current situation with respect to water supply, and evaluates potential options for additional supply. This section also evaluates the City's emergency supply options, and makes recommendations for improved supply.

Evaluation of Existing Supply

As presented in Section 4, a fundamental criteria with respect to supply requires that the main source of supply is capable of meeting current and anticipated peak day demand. It should meet this demand with firm capacity – that is, with the largest pump or other component of the system out of service.

At the present time, the City can produce 5.82 mgd from its groundwater supply, and purchases a constant 0.5 mgd of surface water from CRW on a year-round basis. The total available supply is then 6.32 mgd. The largest component of the existing supply system is well number 7, which produces 1.43 mgd. Therefore, the current firm capacity (i.e., without Well 7 in operation) of the supply is 4.89 mgd.

The current peak day demand (1998) is 5.14 mgd. Therefore, under existing conditions, the supply is unable to meet peak day demand with firm capacity. Projected demand at buildout conditions (2015) is 7.83 mgd. Under buildout conditions, even the ultimate capacity of the supply system will be inadequate to meet peak day needs.

A straight-line projection of population growth vs. water supply indicates that ultimate supply capacity will be outstripped by demand by about the year 2005. The City is vulnerable at the present time to mechanical and electrical failures which could limit its ability to pump the necessary amount of groundwater to meet peak day demands. In five more years, the City may be unable to provide the required amount of water under any conditions, unless steps are taken to ensure additional supply.

To meet projected peak day demands by the year 2015, the City should acquire an additional 3 mgd of firm source capacity. This would bring firm source capacity to 7.9 mgd, and ultimate source capacity to 9.3 mgd.

Potential Source Options

The City has two basic alternatives to develop additional supply – to increase its groundwater production by the development of new wells, or to increase its purchase of surface water from surrounding water providers. In the latter case, potential water providers include the City of Portland, Clackamas River Water and the Oak Lodge Water District. These four alternatives have been evaluated as part of this Master Plan. These alternatives are described briefly below:

Increased groundwater production. The Water Source/Demand Study conducted for the City in 1993 evaluated options for future water supply. This study reported that the Troutdale Aquifer has the hydrologic capacity to meet existing and future demand requirements. Under this option, new wells having a firm capacity of approximately 3 mgd would be required to meet anticipated demands at 2015. As discussed above, additional firm capacity is needed as soon as possible to cover existing peak day demand deficiencies.

Development of a new well would involve hydrologic study to determine well location, site acquisition, water rights permitting through the Oregon Water Resources Department and plan review by the Oregon Health Division. This process would take several years to complete. The City would need to provide information related to the influence of new pumping on the existing contaminant plume to the Oregon Department of Environmental Quality. A clear source of contamination has still not been established. The City would be vulnerable to the risk of moving or spreading the contaminant plume by the drilling and pumping of new wells. This is the most significant disadvantage of pursuing the groundwater option as a means to increase supply.

Contract for purchase from the City of Portland. Under this option, the City of Milwaukie would enter into a purchase agreement with Portland. The two cities are currently upgrading an emergency intertie on Johnson Creek Boulevard at SE 45th Place. The intertie will be capable of providing approximately 2 mgd of emergency supply to Milwaukie. This intertie could also be used to bring non-emergency supply to Milwaukie, under a negotiated agreement.

The City of Portland is a major regional water provider, and maintains wholesale contracts with many surrounding cities and water districts. Portland has provided water to Milwaukie on a sustained basis during the contamination event beginning in 1988, through the existing intertie. Portland is in the process of negotiating new wholesale supply contracts with its current customers, all of which will be renewed in 2004-2007. Until Portland has a clear understanding of the needs of its current customers, Portland will not enter into new agreements for the sale of peak season and peak day supply. Milwaukie's current and projected deficits are peak day deficits. A potential contract with Portland could require a constant rate of flow purchase by Milwaukie, with additional charges for purchase of peaking water above the base amount. This is similar to the current agreement that Milwaukie maintains with CRW.

Contract for purchase from the Oak Lodge Water District. A non-operational intertie between Milwaukie and OLWD is located within OLWD's service area at Where Else Lane. This intertie could be improved to provide additional supply to Milwaukie.

In 1996, OLWD joined with the Mount Scott Water District and the Damascus Water District to form the North Clackamas Water Commission (NCCWC). This agency is responsible for coordinating supply for the three districts. Any supply agreement between Milwaukie and OLWD would therefore be negotiated through the NCCWC.

The NCCWC has constructed a 10 mgd slow sand filter plant on the Clackamas River. OLWD owns 6 mgd of the current plant capacity. OLWD current peak day demands are about 7.5 mgd. These demands are projected to increase slightly over the next 20 years. The OLWD is therefore not currently in a position to provide surplus summer supply to Milwaukie. The NCCWC has recently entered into an agreement with the South Fork Water Board (SFWB) for the purchase of winter water as a back-up supply to the slow sand filter plant, which may not be able to operate during poor water quality conditions. The NCCWC may also purchase surplus summer supply from SFWB at a slightly higher rate.

At the current time, the NCCWC does not have surplus summer water available for sale to Milwaukie. It is possible that, at some future date, based on anticipated expansions of both the SFWB water treatment plant on the Clackamas River and the NCCWC slow sand plant, surplus supply may become available. At the current time however, this is not a viable supply option for Milwaukie. For this reason, an OLWD option was not considered further in the supply evaluation.

Contract for purchase from Clackamas River Water. A connection to the Clackamas River Water (CRW) system was constructed in 1997. The intertie has a firm capacity of 1.0 mgd and an ultimate capacity of 2.0 mgd, and is located at SE Harmony Road near SE Fuller Road in Milwaukie. A formal agreement for the purchase of surplus water by Milwaukie was established in 1997. This 20-year agreement specifies that Milwaukie will purchase surplus water from CRW at a constant amount of 0.5 mgd throughout the year. Between May and September, the purchase is restricted to this uniform rate of approximately 350 gallons per minute (gpm). Outside these months, the total volume remains fixed at 0.5 mgd, but the flow rate may vary throughout the day provided demand does not cause undue stress to the CRW system. In 1998, approximately 20 percent of Milwaukie's annual average demand was met by CRW supply, and 10 percent of the peak day demand was satisfied by CRW supply. The remaining demand was met by the City's groundwater supply.

CRW has the capability to supply Milwaukie, either through the existing intertie or through new metered connections. The unit cost of purchased water will vary depending on the delivery point. Future agreements for water supply would be modeled on the current contract, which specifies a constant rate of flow year-round. During the non-peak season, this rate of flow may vary throughout the day. Similar to the Portland option, CRW has not been assumed to provide Milwaukie with a ready source of peaking water. Both of these options push Milwaukie toward a strategy of wholesale purchases to meet base demand, with the groundwater wells providing peaking supply.

Evaluation Criteria

A qualitative evaluation of potential supply options was conducted as part of this Master Plan. Evaluation criteria were developed with City staff in order to provide a basis for comparison of the alternatives. One quantitative criteria – cost, was also considered in the analysis. An economic comparison of the alternatives is presented later in this section. The qualitative evaluation criteria are described briefly below. The criteria have not been ranked in any order.

Certainty of Supply. Is the water physically available ? Based on the anticipated quantities of water needed, is the potential supply adequate to meet these needs ?

Water Quality. Meets regulatory drinking water standards. Maximizes the consistency of water quality within the distribution system. Minimizes adverse water quality impacts within the distribution and storage system.

Reliability. Given that the quantity of supply is adequate to meet current and projected needs, minimize the short-term disruptions in supply. These episodic or short-term disruptions may be due to emergency events such as power failures, storms, contamination or natural events.

Ease of Implementation. Minimize the magnitude and difficulty of required institutional changes. Minimize the difficulty of completing the required improvements, and of operating the system once it is in place.

Consistency with local and regional planning. The City of Milwaukie, its neighboring water providers and the region as a whole have a history of water system master planning and regional water supply planning that should be considered in the evaluation. Maximize consistency with existing plans and policies.

Compatibility with existing facilities. This criteria will also be reflected in the cost of various options and their ease of implementation, but digs deeper into an understanding of Milwaukie's water system and operation. Maximize the ability of future improvements to integrate into the City's water system.

Ownership/agreements. Maximize the ability of Milwaukie to negotiate favorable agreements and maintain control over its water system.

Evaluation Results

The three source options were evaluated with respect to the criteria presented above. An evaluation matrix is shown in Table 7-1. The relative ratings have been developed in coordination with City staff, based on a current understanding of the issues and constraints associated with each option. All criteria were evaluated qualitatively, with the exception of

cost. A detailed discussion of the relative costs of the three supply options is provided later in this section. Alternatives were ranked as high (H), medium (M) or low (L) according to their perceived ability to meet the criteria.

**TABLE 7-1
SUPPLY EVALUATION MATRIX**

Criteria	Expand GW Source	CRW Connection	Portland Connection
Certainty of Supply	H	H	H
Water Quality	M	H	M
Reliability	H	H	M
Ease of Implementation	H/M	H	H
Consistency with local and regional planning	M	H	M
Compatibility with existing facilities	H	H	H
Ownership / Agreements	H	H	M

All supply options were ranked as high with respect to certainty of supply, as water from the three sources is physically available to serve as a source of supply for the City.

Water quality for the groundwater supply was ranked slightly lower (M) due to past history of contamination and uncertainty surrounding future groundwater expansion and its effect on the contaminant plume. The City of Portland was also ranked slightly lower (M) because of its use of chloramines a residual disinfectant, and potential problems which could occur upon mixing with the free-chlorinated Milwaukie system. Problems have been documented in other systems following mixing of chloramines and free chlorine, including loss of residual and taste and odors. No studies have been conducted in the Milwaukie system to determine whether these negative effects would actually occur. Supply from CRW was ranked high (H)

with respect to water quality. CRW's system is free-chlorinated, making it more compatible with Milwaukie's system. A blending study was conducted in 1998, evaluating the impacts of CRW water blending in Milwaukie's distribution system. Parameters of interest in this study included possible aesthetic effects due to increased corrosion and the disruption of scale deposits on pipe walls. Based on the results of the blending study and on observed experience, blending of CRW supply was not considered to pose a long-term problem for the City.

The groundwater and CRW supplies were rated high (H) with respect to reliability, based on their past history of water availability. The Portland supply was ranked slightly lower for this criteria (M) because in the past few years there have been several major events which have resulted in the Bull Run system being taken off line. These events include a landslide and conduit break in 1996 and a prolonged high-turbidity event in 1999. During these events, Portland requests its wholesale customers to curtail use and/or find alternate sources of water.

Ease of implementation was ranked as high/medium (H/M) for the groundwater and as high for CRW options. Expansion of the groundwater system will be slightly complicated by the presence of contamination in some areas of the aquifer. This will require more effort on the part of Milwaukie to demonstrate that new wells will not influence the movement of contaminants. Milwaukie may also be required or pressured to implement wellhead protection measures at the new sites. It is difficult to say at this time, but ease of implementation for the groundwater expansion could have less than a high rating on this criteria. CRW is a relatively easy option for Milwaukie, as the distribution system is already shared in some areas, a major connection currently exists and an agreement for purchase of wholesale supply already exists between the two entities. The City of Portland option is not as easy to implement, major capital improvements would be required. Contract negotiations with the City of Portland would be more complex and time-consuming.

In terms of consistency with regional planning, the CRW option is most consistent with the long-term vision established by the Regional Water Supply Plan (RWSP) in 1996. The RWSP assumed that future supply for Milwaukie would come from the Clackamas Basin, which has unused capacity, rather than from Portland. In general, local groundwater is envisioned as a backup and peaking supply, rather than a primary source.

Both the groundwater expansion and CRW supply rate high (H) with respect to compatibility with existing facilities, since these two sources are part of the current water supply system. The City of Portland option was ranked slightly lower (M) because it would be essentially a new source of supply.

Finally, the groundwater and CRW options were rated as high (H) with respect to ownership and the ability to negotiate favorable agreements for the City of Milwaukie. The groundwater supply is under the complete ownership and control of the City of Milwaukie. Also, Milwaukie has been satisfied with its contracting arrangements with CRW to date, and is comfortable with its ability to negotiate future agreements in a fair manner. The City of

Portland option was ranked slightly lower (M) because Milwaukie perceives an ability to have less control over terms of agreement, and little opportunity for ownership of the supply.

The CRW source option was rated as high in terms of its ability to meet all criteria. The groundwater supply expansion was the next most highly rated option, followed by the City of Portland alternative. Given the criteria presented above, and the subjective rating developed by the City, the CRW source option emerges as the number one candidate for future supply.

A quantitative economic comparison was also conducted, and the results are discussed below.

Economic Comparison of Supply Alternatives

The three primary source options were compared to determine their relative economic attractiveness. These are planning level costs which are estimated to be accurate within a range of +50 to -30 percent. Several assumptions and conditions were made as part of the analysis. These include:

- The City has an immediate need to increase its firm supply capacity, with an ultimate need of 3 mgd by 2015. This analysis assumes that capital costs to implement each supply alternative would be incurred in the same year, 2001. The expansion of the groundwater supply could occur in increments. However, it is assumed here that the full 3 mgd capacity would be developed at one time. Given the lengthy process of application for water rights, hydrogeologic and water quality testing, acquisition of well sites and construction, it may be advantageous to the City to develop its full groundwater supply capacity at one time.
- For the CRW and Portland options, an operation and maintenance cost of 5 percent of the construction value of the intertie has been assumed. The groundwater option has a higher O&M cost due to energy costs for pumping and treatment costs. Groundwater O&M costs have been developed from previous work by Cunningham Associates, and are described in more detail below.
- The cost of water for the groundwater option was assumed to be zero. The cost of water for the Portland option was assumed to be \$0.76/ccf, based on a May, 2000 estimate from the Portland Water Bureau for the general cost of service to the Milwaukie area, not including possible pumping costs. The cost of water for the CRW option was assumed to be \$0.53/ccf for a new intertie at SE Overland and Linwood Avenue, based on estimates provided by CRW for water supplied from their High Service Zone. The cost of water for the existing intertie was assumed to be \$0.31/ccf, provided from the CRW Low Service Zone. These costs must be verified and could change if Milwaukie enters into serious negotiations with either Portland or CRW.
- An interest rate of 6 percent was used to analyze capital costs. This rate represents typical current bond sale interest rates.

- The cost figures provided do not represent the total cost of the options, but are useful as a means of comparing alternatives. Costs do not include such things as general and administrative costs, or costs to finance construction such as bond counsel or financial advisor and underwriter costs. These numbers do not reflect that fact that annual O&M costs will increase over time due to general inflation.

Economic Evaluation of the Groundwater Option

Capital Cost. Costs for new well construction have been updated from Cunningham Associates 1993 Well Source/Demand Study, based on the current ENR Construction Cost Index (CCI). Cunningham reported the capital cost for a single new well of 800 gpm capacity to be \$531,000 in 1993 dollars. It is assumed that three new wells of this capacity will be required to meet peak day demands in 2015. Three additional wells provide approximately 3.5 mgd of extra capacity to the system. The total capital costs for this option, updated to the year 2000 based on a current CCI of 7153 for the Seattle area, are \$2.04M.

Maintenance Cost. This cost has also been updated from the Cunningham study. That report estimated maintenance costs at approximately 3 percent of the construction value, or \$61,208 in annual costs. It is assumed that these costs accrue each year, and remain constant over the 14 year period from 2001 to 2015. The present worth method was used to convert these future annual costs into a current one-time cost. The net present worth of the maintenance cost, for a 14-year period at 6 percent interest rate is \$568,928.

Operating Cost. Cunningham estimated operating costs for pumping and treatment to be approximately 9 percent of the construction value of the facility. It is assumed that operating costs will increase over time, as groundwater production increases to match demand. Initially, at year 2001, operating costs will be zero, and will rise to 9 percent of construction value by 2015. Because the increase will be linear, an assumed average operating cost of 4.5 percent annually has been used here. The net present worth of the operating cost then becomes \$853,392.

The total cost of the groundwater option, including capital, and annual operating and maintenance costs from 2001 to 2015 is \$3.46M

Economic Evaluation of the CRW Option

For this option, it was assumed that a total additional supply of 3 mgd would be purchased from CRW, with this purchase increasing steadily by year to match increasing demand. The purchase contract would be structured consistent with current agreements, based on a constant rate-of-flow purchase, albeit one which increases incrementally by year. It is assumed that supply would be obtained at two interties, through the existing intertie at Harmony Road, and through a second, new connection at SE Overland and Linwood Avenue. Water delivered to these two points will have different costs, based on the cost to CRW to deliver. It is assumed that by 2015, a total of 2.0 mgd will be delivered to Milwaukie

at the existing intertie connection, which matches the hydraulic capacity of the intertie. Another 1.5 mgd would be delivered at the new intertie, which is the anticipated hydraulic capacity of this intertie without pumping.

Capital cost. Costs for the new intertie have been estimated to be \$313,048, based on assumed pipeline unit costs presented in Section 8 of this Master Plan. Cost estimates do not include vaults, controls or telemetry. Capital costs for the existing intertie are assumed to be sunk costs. Total capital costs for the option are then **\$313,048**.

Operation and maintenance cost. An annual maintenance cost equal to 5 percent of the construction value of the new intertie is assumed, or \$15,652. Maintenance costs for the second, existing intertie are not included because these are sunk costs that would be incurred regardless of an increase in water supply at this point. No operating cost is assumed for this option because there are no pumps or utilities associated with the interties. The net present worth of the maintenance portion of cost is **\$145,485**.

Cost of Water. This cost is by far the largest component of total cost. Under a wholesale purchase option, Milwaukie is committed to annual purchases of water. For the north (new) intertie, it is assumed that supply would increase from 0 to 1.5 mgd at a linear rate, in pace with an increase in demand. The average supply at this point over the 14-year period is then 0.75 mgd. The net present worth of the cost of water, based on an assumed approximate wholesale charge of \$0.53/ccf is then \$1,8700,000. For the south (existing) intertie, it is assumed that supply will increase over the current 0.5 mgd to an ultimate 2.0 mgd at 2015. The net increase is the same here, 1.5 mgd over 14 years, at an average of 0.75 mgd. The wholesale cost of water at this delivery point was assumed to be \$0.31/ccf, for a total cost of water of \$1,050,000. The cost of water for the CRW option over the 14-year period is **\$2.86M**.

The total cost of the CRW option, including capital, and annual operating and maintenance costs from 2001 to 2015 is **\$3.25M**

Economic Evaluation of the Portland Option

For this option, it is assumed that a supply of 3 mgd would be received from Portland at the soon-to-be completed intertie at Johnson Creek Boulevard and SE 45th. It is assumed that this contract could be structured to allow purchase of a constant rate of flow, and in an annual amount which increases incrementally each year to keep pace with demand.

Capital cost. No capital improvements are assumed to be necessary to take the full 3 mgd flow at this intertie. Hydraulic modeling indicates that it is feasible to pass 3 mgd through the intertie. Therefore, all capital costs are sunk costs for this option.

Operating and maintenance cost. No pumping or treatment is associated with the option, therefore operating costs are assumed to be zero. Maintenance costs of 5 percent of the construction value of \$200,000 are assumed. The net present worth of the maintenance cost is **\$92,950**.

Cost of water. Similar to the CRW option, the cost of water is the predominant cost. It is assumed that water is purchased in an amount ranging from zero mgd at year 0, to 3 mgd at year 2015. An average annual purchase of 1.5 mgd over the 14-year period is assumed. A wholesale charge of \$0.76 is used for this analysis. Wholesale rates used in the analysis are very general, and can change based on negotiations between the parties. The net present value of the cost of water for the Portland option is \$5.17M

The total cost of the Portland option, including capital, and annual operating and maintenance costs from 2001 to 2015 is \$5.18M

Conclusions

The relative cost of the potential supply options have been analyzed, and are summarized in Table 7-2. In terms of total cost to the City over the 14-year period 2001 to 2015, the CRW option is roughly comparable to the groundwater option given the accuracy of these estimates. The City of Portland option clearly emerges as the most expensive option, due to the higher wholesale cost of water. The qualitative evaluation of other criteria also ranked the CRW option as the most favorable.

Based on the results of the quantitative economic comparison, and the qualitative evaluation of more subjective criteria, it is recommended that Milwaukie pursue the development of additional supply from CRW to meet projected water demands to 2015.

**TABLE 7-2
ECONOMIC COMPARISON OF ALTERNATIVES**

OPTION	COST (\$M)				
	CAPITAL	OP	MAINT	WATER	TOTAL
GROUNDWATER	2.04	0.85	0.57	0.00	3.46
CRW	0.81	0.00	0.15	2.86	3.82
PORTLAND	0	0.00	0.09	5.17	5.26

Options for Emergency Supply

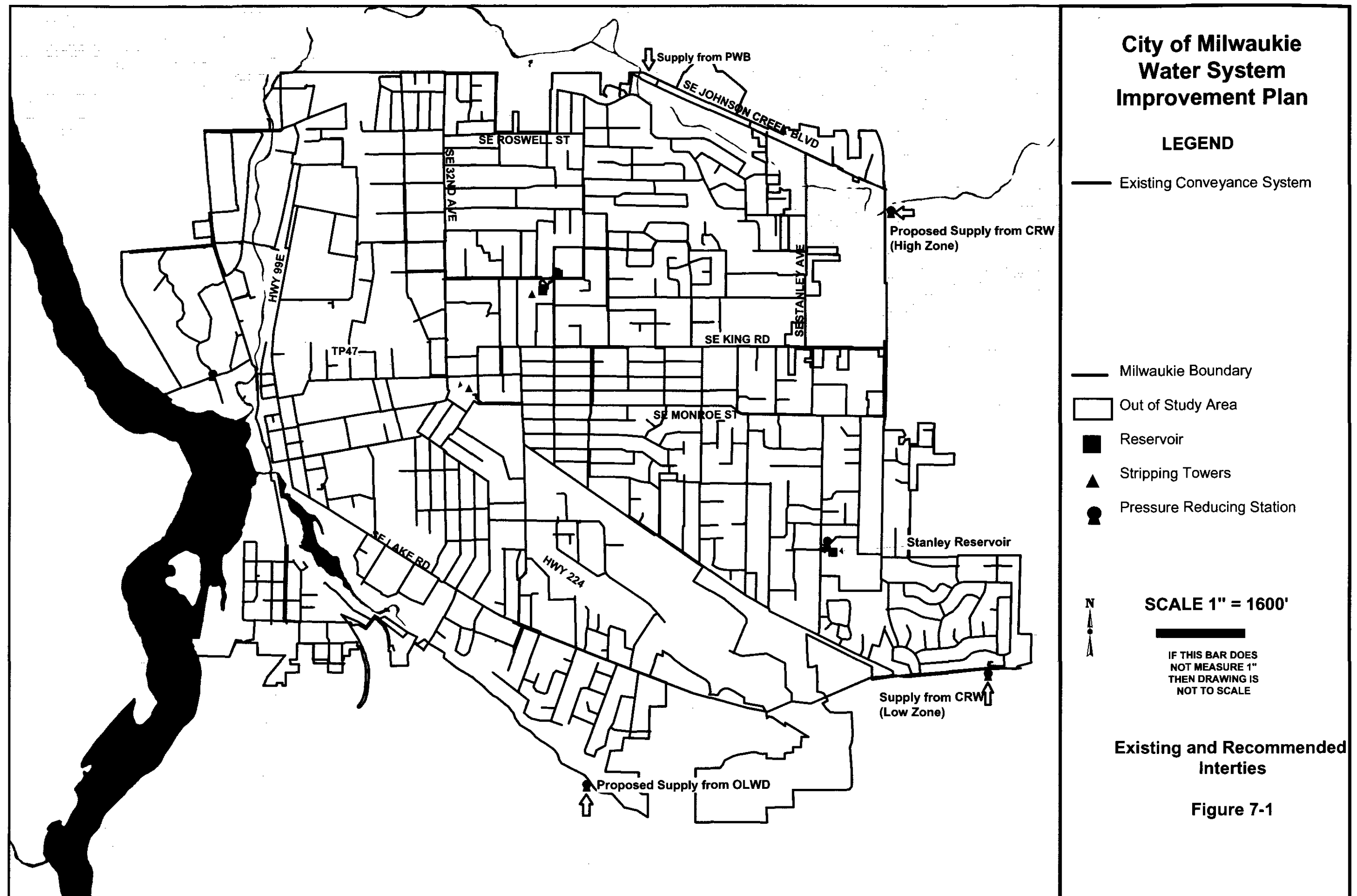
This section has evaluated water supply options, and has recommended that the City move toward a strategy of utilizing base supply from CRW in an amount up to 3.5 mgd, by the year 2015. This strategy establishes a more diversified source for the City, and increases water system reliability. Source diversification is an important aspect of emergency supply as well.

As established in Section 4 – Planning Criteria, the emergency supply should be capable of meeting average day demand for several consecutive days. Projected average day demand in 2015 is about 4 mgd. The City should therefore develop 4 mgd of emergency interconnections with providers *other than* CRW to protect the reliability of the water system. The intertie with Portland which is currently under design will fulfill part of this function. The design capacity of the intertie is 2 mgd. To obtain the remaining necessary emergency supply, it is recommended that the City develop an intertie with the OLWD to provide the remaining 2 mgd.

A recommended intertie to the OLWD would include slightly more than 1,600 linear feet of new 12-inch pipe to replace the abandoned pipeline from Lake Road to Alder Crest Road. The capacity of this intertie would be approximately 3 mgd, based on hydraulics.

This diversity of supply provides Milwaukie with a robust water system. Milwaukie would have access to three completely distinct water supplies – local groundwater, the Clackamas River through CRW and OLWD and the Bull Run/CRSS system through Portland.

Existing and recommended interties are shown on Figure 7-1, along with associated transmission piping.



SECTION 8 – BASIS OF COST ESTIMATES

Cost estimates prepared for this Water Master Plan are planning level opinions of project cost. These opinions of project costs are not definitive predictions of what the costs of any specific project will be when constructed. These estimates have been prepared from the information and data available at the time of this report. The final costs of any project, when constructed, will depend on the actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable factors at the time the project is actually built. As a result, the final actual project costs will vary from the estimates herein.

Costs of the projects are estimated assuming a traditional public works procurement process of design, bidding, award and construction by a licensed contractor using commonly accepted means and methods. Alternative methods of project procurement may result in lower project costs. Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News-Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. The September 2000 ENR CCI of 7153 for the Seattle area construction market (the nearest market ENR monitors) was used as the benchmark for cost estimates in this study. The estimated cost of the facilities should be expected to change along with the accuracy of the estimate as a project proceeds into preliminary and final design. Planning level opinions of project cost are typically within the range of plus 50 percent to minus 30 percent of the average of the contractors bids after adjustments for changes in the ENR index and project scope.

Total capital costs for each project are comprised of several components. These components are the directly estimated construction cost, an allowance for contingencies, and an allowance for engineering, construction management, administrative and legal costs. The allowance for contingencies covers items such as variations in the project configuration that are developed during preliminary design and final design, unforeseen site conditions encountered during construction, and reasonable project changes during construction. The contingency allowance does not include major project scope additions or additional costs resulting from permit mitigation requirements such as wetlands enhancement.

The general basis of the cost estimates for new construction for each type of facility is given below. Any modifications to this general basis, where appropriate, are provided in Section 9, Summary of the Capital Improvement Program.

Pipelines

The assumed costs per foot of installed pipe are shown in Table 8 -1.

TABLE 8 -1
ASSUMED BASIS OF PIPELINE COSTS
(\$/ft of Installed Pipe)

Diameter (inches)	TOTAL \$/ft	Material \$/ft	Installation \$/ft	Subtotal Const. Cost \$/ft	Contingency (20%) \$/ft	Engineering Const. Management & Administrative (15%) \$/ft
6	\$65.15	34.50	13.80	48.30	9.60	7.25
8	\$75.50	39.90	16.00	55.90	11.20	8.40
10	\$90.70	48.00	19.20	67.20	13.40	10.10
12	\$109.65	58.00	23.20	81.20	16.25	12.20
14	\$124.65	65.90	26.40	92.30	18.50	13.85
16	\$146.35	77.40	31.00	108.40	21.70	16.25
18	\$171.00	90.50	36.20	126.70	25.30	19.00
20	\$201.40	106.60	42.60	149.20	29.80	22.40
24	\$275.55	145.75	58.30	204.05	40.90	30.60
30	\$360.00	190.50	76.20	266.70	53.30	40.00

Estimates for pipelines are based on installation in typical urban street environments. Among the basic assumptions upon which the cost estimate is based, unless otherwise noted, are:

- Rights-of-way are in streets with asphalt paving to 4-inch depth. Pavement replacement is assumed to be required for the full project length.
- There are no significant utility relocations required for pipe installation.
- Trenching is in soil, with no rock encountered. Trench width is equal to the nominal pipe diameter plus 2 feet and trench depth assumes cover to top of pipe equal to 3 ½ feet.
- No trench dewatering is required.
- Unless specifically noted, joints are unrestrained.
- Pipe material is ductile iron, Class 52, cement lined and asphalt coated, in the size range of 6-inch to 30-inch diameter.
- Hydrant spacing is 400 feet for mains 18-inch and smaller.
- Two valves per 250 feet for 6-inch to 12-inch pipe, per 350 feet for 14-inch to 20-inch, per 500 feet for 24-inch and 30-inch. Valves are gate valves for 6-inch to 10-inch and butterfly valves for 12-inch to 30-inch piping.
- Projects are in the range of 100 feet to 5,000 feet in length.
- There are no costs for property or easement acquisition.

Use of restrained joints could add 10% to the construction costs. Installation in rock instead of soil could add 10-20% to project costs.

It is recommended that when pipelines are designed, consideration should be given to the use of restrained joints for transmission lines on a case-by-case basis. Restrained joints should be used when transmission pipelines cross unstable land, railroad tracks, freeways, or other locations which could either result in unusual ground movements or could result in significant damage to property or life should a leak occur.

Interties

Costs are based on pipeline unit costs and do not include vaults, controls or telemetry that may be desired by the owner.

Storage Tanks and Reservoirs

The costs for various size ranges of tanks and reservoirs are shown in Table 8-2. These costs are for at-grade steel tank tanks and reservoirs.

TABLE 8-2
ASSUMED BASIS OF STEEL AT-GRADE RESERVOIR COSTS
(\$/gallon)

Size (million gal)	Total Cost (\$/gal)	Constructi on (\$/gal)	Contingenc y (\$/gal)	Engineering, Const. Management Administrative (\$/gal)
0.25	\$0.95	\$0.70	\$0.14	\$0.11
0.50	\$0.77	\$0.57	\$0.11	\$0.09
0.75	\$0.65	\$0.48	\$0.10	\$0.07
1.0	\$0.61	\$0.45	\$0.09	\$0.07
1.5	\$0.53	\$0.39	\$0.08	\$0.06
2.0	\$0.47	\$0.35	\$0.07	\$0.05
3.0	\$0.41	\$0.30	\$0.06	\$0.05

Costs for storage tanks and reservoirs assume construction without any special site constraints or other requirements unless specifically noted. Among the basic assumptions upon which the cost estimate is based, unless otherwise noted, are:

- Reservoirs are constructed of steel.
- Reservoirs are constructed on-grade.

- No rock is encountered for reservoir foundation excavation.
- Landscaping around the reservoir is grass.
- The reservoir exterior is coated with one color of standard tank paint.
- Seismic reinforcement is to Zone 3.
- Piping to bring water to and from the reservoir is located at the site.
- There are no costs for land acquisition or site demolition.
- There are no site or permit constraints which limit the use of the most economical height to diameter ratio for the desired reservoir volume.
- There are no special site environmental or community mitigation costs associated with the reservoir construction.

Seismic requirements for facilities in the Pacific Northwest have changed substantially over the last several years due to increased understanding of seismic risk in the region. It is likely that these requirements will continue to become more stringent. New facilities which are considered "lifeline" are required to have a site specific seismic analysis. Such an analysis could lead to more stringent requirements than the Zone 3 reinforcement assumed in these cost estimates.

Special screening or landscape requirements that are specific to a site could add up to 30% to the costs of a reservoir. Another site consideration is the location of the site relative to existing piping to bring water to and from the reservoir. Sites that are far from existing adequately sized piping would incur additional costs to bring pipes to and from the site.

If it is desired that reservoirs be buried, then steel tanks could not be used. Concrete reservoirs would then be required. Table 8-3 presents the cost basis for concrete tanks. The other assumptions are the same as for the steel reservoirs.

TABLE 8-3
ASSUMED BASIS OF BURIED CONCRETE RESERVOIR COSTS
(\$/gallon)

Size (million gal)	Total Cost (\$/gal)	Construct on (\$/gal)	Contingenc y (\$/gal)	Engineering, Const. Management Administrative (\$/gal)
1.0	\$0.82	\$0.61	\$0.12	\$0.09
1.5	\$0.80	\$0.59	\$0.12	\$0.09
2.0	\$0.77	\$0.57	\$0.11	\$0.09
3.0	\$0.73	\$0.54	\$0.11	\$0.08
3.5	\$0.68	\$0.50	\$0.10	\$0.08

Pump Stations

The costs for various size ranges of installed pumping capacity are shown in Table 8-4.

Costs for pump stations assume construction without any special site constraints or other requirements unless otherwise noted. Among the basic assumptions upon which the cost estimate is based, unless otherwise noted, are:

- No rock is encountered during excavation.
- Landscaping around the site is grass.
- Seismic reinforcement is to Zone 3.
- There are no costs for land acquisition or site demolition.
- There are no special site environmental or community mitigation costs associated with the pump station construction.
- Buildings are of concrete masonry construction.
- Standby generator costs not included unless specifically noted.

**TABLE 8-4
ASSUMED BASIS OF PUMP STATION COSTS
(\$/HP)**

Size Total Installed HP	Total Cost (\$/HP)	Construction (\$/HP)	Contingent y (\$/HP)	Engineering Const. Management Administrative (\$/HP)
50	\$2,970	\$2,200	\$440	\$330
75	\$2,700	\$2,000	\$400	\$300
100	\$2,498	\$1,850	\$370	\$278
200	\$2,025	\$1,500	\$300	\$225
300	\$1,890	\$1,400	\$280	\$210
500	\$1,688	\$1,250	\$250	\$188
1000	\$1,350	\$1,000	\$200	\$150

SECTION 9 – SUMMARY OF CAPITAL IMPROVEMENT AND CAPITAL MAINTENANCE RECOMMENDATIONS

Based on the evaluation of the existing system presented in Sections 6 and 7, this Section describes the recommended Capital Improvement Program (CIP). Projects within the CIP are listed by year for the first five years of the planning period; beginning in fiscal year 2001/2002 and ending in fiscal year 2005/2006, and for the periods 2006-2011 and 2012-2015. Projects are broken down into six categories: pipelines, reservoirs, pump stations, interties, small diameter pipeline replacement and other CIPs. A total of about \$3.1 million in major capital improvements is recommended between now and the year 2015. Another \$1.3 million of small diameter pipeline replacement is recommended by 2015.

This Master Plan listing of CIP projects is intended to be a recommended plan and long-term guide for the development of the City's water system. It is not intended to be a specific list of required projects. While projects are listed in this CIP as being scheduled for construction in a given year, this is intended only to provide a general guideline of priorities, relationships between projects, ties to levels of growth, and understanding of maintenance priorities. Each year the City should review the Master Plan and adopt a specific Capital Improvement and Capital Maintenance Program that incorporates the general guidelines of the Master Plan into the specific activities for that year. The funding source for the recommended projects, whether user fees or system development charges (SDCs), must be determined by the City. The Master Plan should also be reviewed and updated every five years to account for changing circumstances and new information.

Pipeline CIP

About 1.2 miles of pipeline projects were identified to meet peak hour demands and peak day demand plus fire flow for existing and buildout conditions. Recommended pipeline projects are shown in Figure 9-1. These projects have been prioritized into two groups:

- The first priority improvements relieve peak hour demand deficiencies and relieve fire flow deficiencies in the existing system;
- The second priority group relieves deficiencies that will occur as a result of future growth to the year 2015.

About 88 percent of the pipeline CIP will remedy existing deficiencies within the system. The remaining 12 percent of pipeline CIP projects are related to accommodating future growth.

Table 9-1 summarizes pipeline projects in priority group one. Five projects are included in this priority group. In a few cases, where future deficiencies were observed for projects that also require upgrading to meet existing deficiencies, the future upgrade is sized.

Three pipeline projects are included in priority group 2, as well as several recommended pipeline interconnections, to meet future peak hour deficiencies. These are shown in Table 9-2. This priority group includes a major project to correct an existing system deficiency south of Lake Road. Here, a residential area experiences system pressures of less than 40 psi. Because of the magnitude of the capital costs and the relatively mild nature of the problem, the City has elected to classify this project as priority level 2, even though it is an existing system deficiency.

With some exceptions, improvements were assumed to replace the existing pipeline. Water mains along Clatsop St. and McLoughlin Blvd. in Pressure Zone 1 were assumed to parallel relatively new existing pipelines in good condition that are assumed to remain in the ground. New pipeline near Johnson Creek Blvd. and Front St. in Pressure Zone 2 is an operational improvement to create more loops in the system. In all other cases, existing pipelines have been replaced with new pipe.

Reservoirs

Section 6 has discussed storage deficiencies and possible approaches to increasing storage for fire flow, emergency and peaking needs. It is recommended that the City pursue the option of joint storage with the CRW at their existing Otty Road reservoirs. The cost of this storage will be determined through negotiation with the CRW. At this time, it is recommended that the capital cost for new reservoir construction, based on the expected storage deficit, be retained as a placeholder figure for the CIP budget. This capital cost is \$1.5M. The expected cost of this storage was developed in Section 6, and is based on new reservoir construction costs for an at-grade steel tank, with transmission and pumping costs included.

Pump Stations

Pumping facilities are adequate to meet peak day demands in all zones except Zone 4. During peak day demand conditions at the Lava Drive pump station, another 300 gpm pump is needed to ensure service if the existing operating pump is shut down.

The cost for a new 300-gpm (15 hp) operating pump is approximately \$50,000. The pump station upgrade will be complicated by severe space constraints at the site. It is likely that the pump station will need to be relocated. The two existing fire flow pumps and the existing operating pump can be salvaged and re-installed. For the purposes of CIP planning, a capital cost of \$100,000 is assumed for the pump station upgrade. This cost must be evaluated in more detail, based on site availability and engineering design associated with the relocation.

Interties

Section 7 has discussed future water supply options and emergency supply needs. It is recommended that the City pursue construction of a second intertie with CRW at a new location at Linwood Avenue and SE Overland St. The capital cost of the intertie is \$313,000. This intertie would supply Milwaukie with base flow to meet year-round demands, in conjunction with the existing CRW intertie, beginning in 2001.

A second intertie is recommended with the OLWD to meet emergency supply needs. The construction of this improvement, having an estimated capital cost of \$185,000, could be delayed assuming that the City of Portland intertie is completed in 2000-2001 and the second CRW intertie is constructed in the near term. The firm capacity of the current groundwater system is 4.4 mgd, and the anticipated maximum flow from CRW through the two interties is 4.0 mgd (2.5 mgd through the south intertie, 1.5 mgd through the north intertie). The Portland intertie has an assumed capacity of 2 mgd. This total flow of 10.4 mgd is adequate to meet peak day demands plus emergency demands until about 2009. Therefore, the OLWD intertie project can be delayed to the 2005-2010 timeframe.

Table 9-3 provides a summary of intertie capital costs.

Table 9-4 is a summary of the recommended CIP projects and proposed improvement schedule. The CIP schedule is weighted toward expenditures in the first five years of the planning period, due to the need to correct existing system deficiencies in pipelines, storage and supply. The prioritization of these projects must be further analyzed by the City based on available resources. The CIP schedule allocates approximately \$700,000 to \$750,000 for the first three years. Thereafter, for the next eight years, CIP allocations drop from \$350,000 to about \$280,000 per year. The CIP can be completed by 2011 according to this schedule.

Small Diameter Pipeline Replacement

This section of the CIP has been broken out as a separate element of the pipeline improvement projects. The small-diameter pipeline replacement program includes all pipeline less than 6 inch diameter, as well as all pipeline identified as unlined cast iron material. Approximately 17 miles of 4-inch pipeline exists in the City's distribution system. This pipeline is inadequate to meet existing peak day plus fire flow demands and should be replaced with 6-inch diameter pipe. This is a significant element of the total budget, because of the sheer number of pipeline segments involved. The total estimated capital cost for small pipeline replacement is about \$1.3 million.

Table 9-5 summarizes the small diameter pipeline replacement program. It is recommended that the City move methodically through this program to remove aging and inadequate pipe. The projects shown in Table 9-5 prioritize the replacement effort, with the most critically needed improvements listed at the top of the Table, moving to less essential improvements. Each pipeline project was prioritized by length of pipe (longer pipe segments were given higher priority), proximity to transmission line, and connectivity to other pipe. If a small

segment of pipe had longer segments of larger diameter pipe on either side of it, it received a higher priority than the remaining projects. Projects which are already included in the City's pipeline replacement program are noted in the Table.

The small diameter pipeline replacement program is included in the CIP shown in Table 9-4. It is recommended that the priority 1 projects be carried out in the first five years of the CIP. Priority 2 projects are scheduled for the 2006-2011 period, and priority 3 projects are scheduled for completion in the 2012-2015 period.

Other Capital Improvement Projects

The CIP schedule shown in Table 9-4 includes other, minor recommended projects. Briefly, these projects include:

- Updates of the water master plan every ten years;
- Completion of the seismic strengthening recommendations on the elevated tank, prepared by Cunningham and Associates;
- A pump efficiency study. In *Section 6–Evaluation of the Existing System*, it was recommended that all of the City's pumps and motors be evaluated and rated against their expected production and efficiency. This evaluation will identify pump and motor replacement and maintenance needs.
- Internal tank inspections.
- External tank inspections.

Table 9-1
PRIORITY 1 PIPELINE
IMPROVEMENTS

PID	LINE NO.	DESCRIPTION	DATE	STATUS	LENGTH (FEET)	DIAMETER (INCHES)	DEPTH (FEET)	WIDTH (FEET)	HEIGHT (FEET)	AREA (SQ. FEET)	VOLUME (CU. YD.)	EST. COST (\$)	ACT. COST (\$)
P003	2	Harlow St. from Stanley Ave. to 56th Ave.		x	4	6				6	442	\$ 65.15	\$ 28,796
P004	2	Along Harvey St. from 40th Ave. to 42nd Ave. Parallel existing 12-inch pipeline.		x	4	6	8		10	10	535	\$ 90.70	\$ 48,525
P004	2	Along 42nd Ave. from Harvey St. to Howe St. Interconnect existing 12-inch pipeline with new pipeline at 40th and Harvey and 42nd and Harvey		x	4	6	8		10	10	570	\$ 90.70	\$ 51,699
											1,105		\$ 100,224
P005	1	Along Clatsop St. from west of 23rd Ave. to McLoughlin Blvd. Along McLoughlin from Clatsop St. to Moores St., along Moores St.		x	6	12				12	1,450	\$ 109.65	\$ 158,993
P006	1	Along Ochoco St. from 17th Ave. to McLoughlin Blvd.		x	-	12				12	450	\$ 109.65	\$ 49,343
TOTAL PRIORITY 1 COST											3,005		\$ 337,355

Table 9-2
PRIORITY 2 PIPELINE
IMPROVEMENTS

P007	2	Shell Ln. from Lake Rd., Shell Ln. to Guilford Ct. Guilford Ct. to Oatfield Rd., along Oatfield Rd.	x				10	12				12	2,730	\$ 109.65	\$ 299,345
P008	2	Intersection of 43rd Ave. and Howe St. (Interconnect)				x	--		8			8	25	\$ 75.50	\$ 1,888
P009	2	Intersection of 44th Ave. and Howe St. (Interconnect)				x	--		8			8	15	\$ 75.50	\$ 1,133
P011	2	Intersection of 38th Ave. and Harvey (Interconnect 6 & 18-inch)				x	--				8	8	10	\$ 75.50	\$ 755
P011	2	Intersection of 37th Ave and Harvey (Interconnect 6 & 18-inch)				x	--				8	8	10	\$ 75.50	\$ 755
													20		\$ 1,510
P013	2	Intersection of Howe St. and 42nd Ave.				x	8				12	12	10	\$ 109.65	\$ 1,097
P014	2	42nd Ave. from Howe St. to Olsen St.				x	8				10	10	720	\$ 90.70	\$ 65,304
P015	2	Intersection of 42nd Ave. and Covell St. (Interconnect)				x	--				12	12	10	\$ 109.65	\$ 1,097
TOTAL PRIORITY TWO COST													3,530		\$ 371,372

TABLE 9-3
INTERTIE IMPROVEMENTS

Project ID	Length (ft)	Description	Material	Quantity	Unit Cost (\$)	Total Cost (\$)	Notes
P016	2	Stanley Ave. from JCB to Firwood St. (1.5 mgd from CRW)	x	8	10	10	1,133 \$ 90.70 \$ 102,763
P016	2	Along JCB from SE Linwood, to SE Stanley Ave.	x	12	14	14	1,577 \$ 124.65 \$ 196,573
P016	2	Along SE Linwood Ave. near SE Overland St.	x	12	14	14	110 \$ 124.65 \$ 13,712
							2,820 \$ 313,048
P017	2	SE Where Else Ln. to Lake Rd. along existing 16 inch alignment (3 mgd from OLWD)	x	16 (Abandoned)	12	12	1,687 \$ 109.65 \$ 184,980
TOTAL INTERTIE COST							4,507 \$ 498,027

capital costs are based on pipeline unit costs, and do not include vaults, controls and telemetry

**TABLE 9-4
CAPITAL IMPROVEMENT SCHEDULE**

	1-Year	1-Year	1-Year	1-Year	1-Year	5-Year	3-Year
Interties:							
CRW Intertie	\$ 313,048						
Oak Lodge Intertie						\$ 184,980	
Reservoirs:							
Otty Rd. 1.5 mg initial capacity		\$ 400,000	\$ 400,000				
Otty Rd. 1.5 mg additional capacity					\$ 200,000	\$ 600,000	
Pump Stations:							
Lava Dr. PS	\$ 100,000						
Pipelines:							
P003 <i>priority 1</i>	\$ 28,796						
P004 <i>priority 1</i>	\$ 100,224						
P005 <i>priority 1</i>		\$ 158,993					
P006 <i>priority 1</i>			\$ 49,343				
P007 <i>priority 2</i>			\$ 149,672	\$ 149,672			
P008 <i>priority 2</i>				\$ 1,888			
P009 <i>priority 2</i>				\$ 1,133			
P011 <i>priority 2</i>				\$ 1,510			
P013 <i>priority 2</i>				\$ 1,097			
P014 <i>priority 2</i>				\$ 65,304			
P015 <i>priority 2</i>				\$ 1,097			
Small Diameter Pipelines:							
priority 1,2,3	\$ 130,000	\$ 130,000	\$ 130,000	\$ 130,000	\$ 130,000	\$ 526,850	
Other CIP:							
Master Plan update						\$ 70,000	
Complete seismic recs (Elevated tank)		\$ 20,000					
Pump Efficiency study	\$ 15,000						
Internal tank inspection	\$ 35,000						
External tank inspection	\$ 20,000					\$ 35,000	

TABLE 9-5
4" PIPELINE IMPROVEMENTS

1	P001	2	43rd Ave. from Rhodessa to King Rd.	x				4	6				6	650	\$ 65.15	\$ 42,348
1	P001	2	Franklin St. from 42nd Ave. to 45th Ave.	x				4	6				6	720	\$ 65.15	\$ 46,908
1	P001	3	54th Pl. to Woodhaven St., Woodhaven St. to Stanley Ave.	x				4	6				6	1,388	\$ 65.15	\$ 90,428
1	P001	2	Monroe St. from 42nd Ave. to 47th Ave.	x				4	6				6	1,296	\$ 65.15	\$ 84,434
1	P001	2	37th Ave. from Harvey St. to King Rd.	x				4	6				6	1,280	\$ 65.15	\$ 83,392
1	P001	3	55th Ave. from King Rd. to Monroe St.	x				2	6				6	1,206	\$ 65.15	\$ 78,571
1	P001	2	Howe Ln. from 46th Ave. to 44th Ave., 44th Ave. from Howe Ln to Howe St.	x				4	6				6	1,191	\$ 65.15	\$ 77,594
1	P001	2	Drake St. from 38th Ave. to 40th Ave., 38th Ave. from Drake St. to King Rd.	x				4	6				6	1,103	\$ 65.15	\$ 71,860
2	P001	2	Balfour St. from 29th Ave. to 32nd Ave.	x				4	6				6	990	\$ 65.15	\$ 64,499
2	P001	2	29th Ave. from Van Water St. to Roswell St.	x				4	6				6	953	\$ 65.15	\$ 62,088
2	P001	2	Winworth Ct. near Willow St.	x				4	6				6	933	\$ 65.15	\$ 60,785
2	P001	2	Rio Vista St. from 42nd Ave. to 45th Ave.	x				4	6				6	787	\$ 65.15	\$ 51,273
2	P001	2	28th Pl. from Van Water St. St. to Roswell St.	x				4	6				6	711	\$ 65.15	\$ 46,322
2	P001	2	Malcolm St. from 29th Ave. to 32nd Ave.	x				4	6				6	711	\$ 65.15	\$ 46,322
2	P001	2	Olsen St. from 29th Ave. to 32nd Ave.	x				4	6				6	710	\$ 65.15	\$ 46,257
2	P001	2	30th Ave. from Van Water St. to Roswell St.	x				4	6				6	700	\$ 65.15	\$ 45,605
2	P001	2	31st Ave from Van Water St. to Roswell St.	x				4	6				6	695	\$ 65.15	\$ 45,279
2	P001	2	34th Ave. from Washington St. to Sellwood St.	x				4	6				6	667	\$ 65.15	\$ 43,455
2	P001	3	Waymire St. from 56th Ave. to Stanley Ave.	x				4	6				6	614	\$ 65.15	\$ 40,002
2	P001	3	35th Ave. from Washington St. to Sellwood St.	x				4	6				6	401	\$ 65.15	\$ 26,125
2	P001	2	Llewellyn St. from 32nd Ave. to 34th Ave.	x				4	6				6	562	\$ 65.15	\$ 36,614
2	P001	2	North on 33rd Ave. from Harvey St.	x				4	6				6	532	\$ 65.15	\$ 34,660
3	P001	2	39th Ave. from Wake St. to Filbert St.	x				4	6				6	504	\$ 65.15	\$ 32,836
3	P001	2	Sequoia Pl. from Plum Dr. to Sequoia Ave.	x				4	6				6	253	\$ 65.15	\$ 16,483
3	P001	2	Myrtle St. near Campbell St.	x				4	6				6	251	\$ 65.15	\$ 16,353
3	P001	1	Scott St. from Main St. to McLoughlin Blvd.	x				4	6				6	251	\$ 65.15	\$ 16,353
1	P001	2	King Rd. from 40th Ave. to 44th Ave	x				4	--				Transfer	1,350	TBD	TBD
1	P001	2	King Rd. from 52nd Ave. to Stanley Ave	x				4	--				Transfer	992	TBD	TBD
1	P001	2	43rd Ave. from Rockwood St. to Rhodessa Rd.	x				4	--				Transfer	1,425	TBD	TBD
1	P001	2	Rockwood St. from 46th Ave. to 49th Ave.	x				4	--				Transfer	580	TBD	TBD
1	P001	2	42nd Ave. from Jackson St. to Franklin St.	x				4	--				Transfer	1,550	TBD	TBD
1	P001	2	Along Roswell St. from 32nd Ave. to 37th Ave.	x				4	--				Transfer	1,380	TBD	TBD
1	P001	2	46th Ave from Rockwood to Howe	x				4	--				Transfer	1,380	TBD	TBD
1	P001	2	Howe St. from 42nd Ave. to 46th Ave.	x				4	--				Transfer	1,206	TBD	TBD
1	P001	3	Linwood Ave. from King Rd. to Monroe St.	x				4	--				Transfer	1,201	TBD	TBD
1	P001	2	From 37th Ave., from north of Kehrl Dr. to Lake Rd.	x				4	--				Transfer	1,170	TBD	TBD
2	P001	2	42nd Ave. from Jackson St. to Adams St.	x				4	--				Transfer	789	TBD	TBD
2	P001	2	42nd Ave. from King Rd. to Jackson St.	x				4	--				Transfer	765	TBD	TBD
2	P001	2	32nd Ave. from Kelvin St. to Balfour St.	x				4	--				Transfer	516	TBD	TBD
2	P001	2	Kelvin St. from 29th Ave. to 32nd Ave.	x				4	--				Transfer	685	TBD	TBD
TOTAL 4' PIPELINE COST																\$1,306,844

