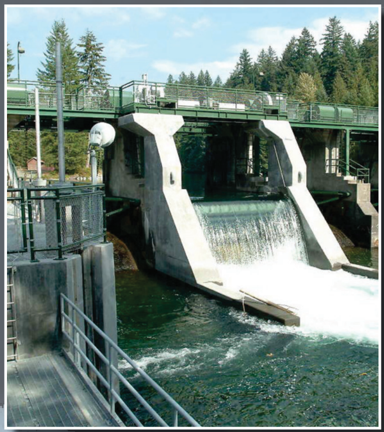
Seattle Public Utilities

2007 Water System Plan

Our Water. Our Future.



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Seattle Public Utilities

2007 Water System Plan
November 2006

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Abbreviations

The following table defines abbreviations that are used frequently in this *Water System Plan*:

ASR	Aquifer Storage and Recovery
AWWA	American Water Works Association
AwwaRF	American Water Works Association Research Foundation
BMPs	Best Management Practices
BPA	Bonneville Power Administration
CCF	hundred cubic feet
CCL2	Second Candidate Contaminant List
CCP	Concrete cylinder pipe
CCR	Consumer Confidence Report
CFP	Capital Facilities Plan
CI	cast iron
CIP	Capital Improvement Program
CO	carbon monoxide
COMPLAN	King County Comprehensive Plan
CPA	Conservation Potential Assessment
CRW CRMP	Cedar River Watershed Cultural Resources Management Plan
CRW HCP	Cedar River Watershed Habitat Conservation Plan
CRWEC	Cedar River Watershed Education Center
CUE	Conjunctive Use Evaluation
CWA	Cascade Water Alliance
CWSP	Coordinated Water System Plan
DI	ductile iron
DNS	Determination of Nonsignificance
EDC	Endocrine Disrupter Chemicals

EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
F	Fahrenheit
FCF	Flow Control Facilities
FERC	Federal Energy Regulatory Commission
FWP	Finished Water Pipelines
GCM	General Circulation Model
GIS	Geographic Information System
GMA	Growth Management Act
GPS	Global Positioning Satellite
HCP	Habitat Conservation Plan
HPA	Hydraulic Project Approval
I-63 SO	Initiative 63 Settlement Ordinance (Seattle Ordinance 120532)
IFA	Instream Flow Agreement
IPCC	Intergovernmental Panel on Climate Change
IWA	International Water Association
LAF	Limited Alternative to Filtration
LED	light-emitting diodes
LEED	Leadership in Energy and Environmental Design
LT2SWTR	Long Term 2 Surface Water Treatment Rule
LUAs	Limited Use Areas and Trails
MAC	Mycobacterium Avium Complex
MBR	membrane bioreactor
MCL	Maximum Contaminant Level
mgd	million gallons per day
MTBE	methyl tertiary butyl ether
MWL	Municipal Water Law
NCAR	National Center for Atmospheric Research

No.	Number
NPV	Net Present Value
O&M	Operation and Maintenance
OAHP	Office of Archaeological and Historic Preservation
OMI	Operations Management International
PDP	Project Development Plan
PHSKC	Public Health Seattle and King County
PPCP	Pharmaceuticals and Personal Care Products
PSCAA	Puget Sound Clean Air Agency
psi	pounds per square inch
PV	Present Value
RWSP	Regional Wastewater Services Plan
SAMP	Strategic Asset Management Plan
SCADA	Supervisory Control and Data Acquisition
SMP	Shoreline Master Program
SPU	Seattle Public Utilities
SRES	Special Report on Emission Scenarios
SWTR	Surface Water Treatment Rule
TPL	Tolt Pipeline
TPL1	Tolt Pipeline Number 1
USGS	United States Geological Survey
UV	Ultraviolet
UW-CIG	University of Washington Climate Impacts Group
WAC	Washington Administrative Code
W.D.	Water District
WDOH	Washington State Department of Health
WSAA	Water Services Association of Australia
WSP	Water System Plan

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2007 Water System Plan
Executive Summary

Seattle Public Utilities (SPU) manages and operates the water system serving Seattle residents and wholesale customers in nearby cities and water districts. This *2007 Water System Plan* describes how SPU meets current and future water demands, ensures high quality drinking water, maintains its water system at the lowest cost, and continues its legacy of environmental stewardship.

It is clear that uncertainties surrounding the Puget Sound region's population growth, the degree of economic activity, and the potential impact of climate change will affect future demand for water and the possible need for new sources of supply. Sophisticated planning tools have been developed by SPU to analyze the impact of a range of variables over the next 50 years. SPU uses these tools to facilitate discussion and evaluate future scenarios in order to make cost-effective, responsible decisions while meeting environmental goals.

Planning for uncertainty is the framework under which this *2007 Water System Plan* was prepared, and this framework is particularly evident in the analysis related to the water demand forecasts and water supply alternatives. This analysis indicates that no new water supply sources are needed for SPU for many decades, even when factoring in potential climate change and continued population growth.

The *2007 Water System Plan* articulates SPU's commitment to:

- Ensuring a long-term, high-quality water supply while protecting the environment and fishery resources.
- Using asset management principles in business decisions to provide the highest value to ratepayers over the long-term.
- Continuing to be a leader in water conservation.
- Being customer-driven.
- Working together with other water providers and regional jurisdictions to address water issues.

PURPOSE OF THE WATER SYSTEM PLAN

SPU prepared the plan under regulations adopted by the Washington State Department of Health (WDOH) for public drinking water suppliers. The plan is also consistent with the WDOH Water Use Efficiency Proposed Draft Rule, requirements of the Growth Management Act, and local and regional land use plans.

SIX YEARS OF INNOVATION AND PROGRESS: 2001-2006

SPU has accomplished much and made significant forward progress since the prior *2001 Water System Plan* was published. Significant accomplishments are highlighted below.

SPU Progress and Changes since the *2001 Water System Plan*

Accomplishments	Description
Improved Business Practices	Shifted to an asset management approach that has intensified SPU focus on the delivery of cost-effective service to customers – today and into the future. This facilitates decision-making that values environmental and social benefits while minimizing expenditures.
Signed New Wholesale Contracts	Signed a long-term declining block contract with the Cascade Water Alliance (Cascade). The contract provides certainty about the amount of water Cascade member utilities will purchase from SPU through 2053 and reduces the long-term demand on the system.
Negotiated Agreements to Secure the Future	Negotiated an agreement with the Muckleshoot Indian Tribe for the Cedar River that strengthens protection of in-stream resources, establishes greater certainty for the region's water supply, supports Tribal treaty rights, and creates a positive framework for resolving future issues with the Tribe.
Saved Water	Provided water conservation programs to customers that are among the most aggressive and effective in the country, producing a continuing decline in per capita demand.
Protected Fish Habitat	Implemented new habitat and source water protection efforts in Seattle's municipal watersheds, including passage for three species of anadromous fish above the Landsburg Diversion Dam–ending 100 years of blockage and opening up 17.5 miles of protected fish habitat on the Cedar River.
Improved Drinking Water Quality	Brought online state of the art water treatment facilities for the Cedar River and South Fork Tolt supplies designed to protect public health, meet regulations for the foreseeable future, and improve the water's taste and odor.
Met Regulatory Requirements	Resolved two WDOH compliance agreements, the Cedar Agreed Order, and the Lead and Copper Bilateral Compliance Agreement.
Covered In-Town Reservoirs	Covered or buried several in-town reservoirs, in compliance with SPU's Reservoir Covering Plan, to enhance protection of drinking water quality while providing open space and improved community amenities.
Safeguarded the Water System	Completed post-9/11 vulnerability assessments and security improvements to safeguard the water system from intentional or accidental emergency events.
Enhanced System Reliability	Completed several other major capital projects to increase reliability of the water system, including: • Replacement of the SCADA system used for monitoring and control. • Addition of a second Tolt transmission pipeline.

CONTENTS OF THE *2007 WATER SYSTEM PLAN*

The *2007 Water System Plan* includes:

- Revised and updated polices to guide SPU and how it conducts business.
- Service levels for managing the system and reporting performance to customers.
- A commitment to regional conservation goals that extends through 2030.
- An updated official water demand forecast and analysis of future supply options, including new sources, enhancement of existing resources, reclaimed water projects, desalination of seawater, and increased conservation.
- Strategies for meeting future challenges and uncertainties, including potential impacts of climate change on water supplies, emerging water quality issues, and aging infrastructure.
- An evaluation of the water system and its various facilities and components, including condition of key assets and implementation plans to address needs, gaps, and issues for each of SPU's water line business areas.

HIGHLIGHTS FROM *2007 WATER SYSTEM PLAN*

SPU has reorganized its water system operations into business areas, each of which has responsibility for managing a facet of the overall water utility. Each business area has developed strategies and action plans for the next six years and beyond. Key implementation actions for each business area are highlighted below.

Water Resources Business Area

Landsburg Diversion Dam

The Water Resources business area ensures that SPU water customers will have sufficient water to meet their short-term and long-term needs while protecting instream resources.

Year-to-year climate variability has been an issue in the past, and will continue to be in the future. SPU will continue to actively manage its water resources and will make improvements to ensure additional system flexibility and reliability.

Key water resource findings and actions in this plan include:

- A commitment to existing water conservation programs along with an additional 15 mgd of average annual conservation savings from 2011-2030.
- Official forecast indicates no new source of water supply needed until after 2060.
- A climate change scenario shows that a 50 percent loss in average snowpack could result in a 10 percent loss in firm yield by 2040. If so, a new source of supply would be needed in 2055.
- There is no need to invest in a new supply source at this time, even after considering the uncertainties around the factors that influence water demand and the potential impacts climate change could have on supply.
- Keep the current menu of supply options open and review if/when significant decisions need to be made about investing additional funds into such supply options.
- At least every six years or as new information is known about the supply-demand outlook and supply alternatives, update the evaluation of potential future sources of supply for cost, source development issues, environmental impacts, and public trust values.
- Change in the place of use of the Cedar River and Lake Youngs water rights claims to the SPU service area, as allowed by the 2003 Municipal Water Law.
- Continued exploration of adaptive management strategies and operational changes to optimize use of existing water sources.
- Plans to improve water supply facilities, including the Morse Lake dead storage facilities and Landsburg Diversion Dam.

Water Quality and Treatment Business Area

Water quality analyst at SPU's laboratory

The Water Quality and Treatment business area ensures that SPU provides water that meets or exceeds drinking water quality regulatory requirements to not only protect public health, but ensure drinking water is aesthetically pleasing to customers in terms of appearance, taste, and other factors.

Key water quality and treatment actions identified in this plan include:

- Completing the reservoir covering program, including decommissioning of one or two in-town reservoirs.
- Exploring approaches to help SPU customers maintain excellent water quality in their own plumbing systems.
- Monitoring and investigating ways to improve or protect drinking water quality, such as completion of studies for Kerriston Road and Lake Youngs.
- Keeping abreast of emerging water quality issues to ensure that SPU water quality meets regulations for years to come.

Transmission and Distribution Business Area

Installation of the Tolt Transmission Pipeline

The primary challenge for the Transmission and Distribution business area is to cost-effectively manage aging facilities while meeting service levels for water delivery to wholesale and retail customers.

Key transmission and distribution actions identified in this plan include:

- Implementing strategies for managing transmission and distribution system assets, including implementation of the cathodic protection program for transmission pipelines.
- Improving areas in the distribution system that have lower water pressure than required under established service levels.
- Improving the ability of Cedar or Tolt sources to serve more of the service area by implementing supply transfer and transmission improvements that prove to have a positive net present value to customers.

POLICIES AND SERVICE LEVELS

Revised and updated polices for SPU's water business areas have been developed and are summarized in the table below. These policies will guide SPU and how it conducts business.

Service levels for SPU's water business areas have also been developed. They are statements of desired performance outcomes that are of high priority to SPU's customers or required by regulators. SPU utilizes service level objectives – broad statements of intent – to establish the direction of each of its business areas while using service level targets to establish measurable performance goals.

Policies to Guide SPU's Water System Activities

Policy	Policy Statement
Asset Management	Use Asset Management principles to guide all capital and O&M financial decisions to deliver services effectively and efficiently.
Environmental Stewardship	Protect and enhance the environment affected by the utility as it carries out its responsibilities to provide drinking water.
Security and Emergency Preparedness	Institute and maintain appropriate safeguards to protect against security risks and sustain emergency response readiness to ensure the continuity of drinking water services, including fire protection service.
Meeting Customer Expectations	Provide retail and wholesale drinking water service that responds to changing customer expectations centered on providing reliable, high-quality water, and guided by asset management principles.
Service Area	Continue providing service within the service area boundary as defined in the *2001 Water System Plan*, allowing for new customers within that area at SPU's discretion.
Regional Role and Partnerships	Be a leader in seeking regional cooperation and efficiencies that benefit the customers of SPU, other water utilities, and the environment.
Planning for Uncertainty	Base supply investment strategies on future outlooks for supply and demand that incorporate an evaluation of uncertainties using the best available analytical tools.
Supply Reliability	Plan to meet full water demands of "people and fish" under all but the most extreme or unusual conditions, when demands can only be partially met.
Resource Selection	In planning to meet future customer demand, select new sources of supply from all viable options, including conservation programs, improvements to system efficiencies, use of reclaimed water, and conventional supply sources, based on triple-bottom-line analysis.
High-Quality Drinking Water Provision	Manage drinking water quality from the water source to the customer taps in coordination with wholesale customers to protect public health, comply with drinking water quality regulations, and maintain and improve public confidence in the drinking water quality.
Watershed Protection	Control human activity and be prepared to respond to emergencies in the municipal watersheds to maximize protection of drinking water source quality.
Transmission System Redundancy	Consider redundancy in the transmission system on a case-by-case basis, with decisions based on an evaluation of net present value.
Access to Seattle Regional Water System	Evaluate requests for access to the Seattle regional water system using the *Access to Seattle Water System Guidelines*, based on the unique characteristics of the water that would be moved through the system.
Distribution System Redundancy	Consider redundancy for the distribution system on a case-by-case basis, with decisions based on an evaluation of net present value.

The *2007 Water System Plan* represents SPU's first effort to document service level objectives and targets, and monitor the utility's success at meeting those targets. As part of its asset management initiative, SPU will continue to track its performance relative to those targets, assess its cost-effectiveness in meeting the service levels, and seek input from customers on their willingness-to-pay for the levels of service SPU provides.

PLAN IMPLEMENTATION

Implementation of this *2007 Water System Plan* requires completion of capital projects, programs, and operations and maintenance (O&M) activities. Cost estimates for these new and ongoing efforts are included in this plan, along with projected impacts to water rates. Funding levels and rates are subject to approval by City Council through the regular budget and rate adoption processes.

Capital Facilities Budgeting

SPU's draft Capital Facilities Plan totals more than $1 billion from 2007 through 2030. Approximately one-third of this total is for replacement or rehabilitation of infrastructure that has reached the end of its economic life. SPU anticipates significant annual spending in the near-term to accommodate several major projects, such as the reservoir burying program. Once these major capital projects have been completed, capital facility spending is expected to decline. However, beyond 2012 there is a greater range of uncertainty. Experience has shown that new requirements emerge and projections change.

Operation and Maintenance Cost Outlook

As infrastructure ages, the costs associated with repairs increase, at least until those assets are replaced. SPU expects annual O&M costs to increase by approximately $3 million (in 2006 dollars) by 2030, due primarily to the increasing costs of repairing aging water mains in its distribution system.

Financial Program

SPU's water system is experiencing a period of capital expenditures not required since the system was originally constructed 100 years ago. SPU has been making, and continues to make, significant investments to protect public health, comply with federal and state regulations, and replace aging infrastructure.

In order to pay for required facilities and improvements, and particularly to pay off debt for those facilities recently added, rate increases moderately higher than the rate of inflation are projected until about 2015. After 2015, rates should stabilize and begin decreasing in real terms.

CONCLUSION

The past six years have been highly productive for SPU's water line of business. As a result of SPU's attention to water supply planning, SPU is moving forward with confidence that its existing supplies are adequate for at least another 50 years. At the same time, SPU and many of its wholesale customers have made a commitment to continue investments in water conservation.

In addition, SPU's water quality improvements, such as its new treatment facilities and reservoir burying program, are helping to ensure that high drinking water quality is preserved for its customers. Finally, SPU's asset management initiative is helping to ensure that long-term costs to ratepayers are minimized without decreasing the level of service below established targets. All of SPU's efforts aim to provide its customers with excellent service at minimum costs, now and into the future.

PART I: DIRECTION FOR BUSINESS AREAS

Part I of this *2007 Water System Plan* presents SPU's water system capital facilities and operation and maintenance "roadmap" for the next 20 years and beyond. After an introductory chapter to establish context for this updated plan, the balance of Part I presents the substance of that "roadmap" for each business area of SPU's water line of business. Part II focuses on the anticipated costs of implementing that roadmap over the next six years and through 2030.

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Chapter 1
Introduction

Seattle Public Utilities (SPU) provides drinking water to a service area population of 1.45 million within the greater Seattle metropolitan region of King County and small portions of southwest Snohomish County.

As part of its continuing effort to meet or exceed all drinking water regulations, and in response to input SPU has sought from its retail and wholesale customers regarding the need for reliable, high-quality, and affordable water service, SPU has prepared this *2007 Water System Plan* in accordance with Washington State Department of Health (WDOH) requirements. This introductory chapter includes a brief history and description of the existing water system and of the four business areas that comprise SPU's water line of business to provide context for this plan.

In addition, this chapter presents an overview of SPU's asset management business framework, which guides how SPU conducts business. The chapter also contains a description of the current planning environment, including changes as a result of the Municipal Water Law adopted by the Washington State Legislature, other regional planning efforts in SPU's service area, and the potential impacts of future climate change on SPU's water system and its customers. Finally, the introduction summarizes the organization of this plan and describes how it meets the requirements of the Washington Administrative Code (WAC).

1.1 INTRODUCTION TO DRINKING WATER LINE OF BUSINESS

The mission of SPU's water line of business is to provide reliable, high-quality water for people and fish.

In addition to operating Seattle's regional drinking water system, SPU also provides surface water drainage, wastewater, solid waste, and engineering services to residents of Seattle. This plan covers SPU's drinking water line of business. This section provides background on the water system and the water utility's organizational structure.

1.1.1 History of Water Business

Since 1901, the Cedar River has provided water for Seattle. Initially, there was a diversion dam and transmission pipeline on the lower Cedar River at Landsburg and a timber crib dam at Cedar

Lake–later renamed Chester Morse Lake. In 1914, a higher masonry dam was constructed to create storage for Seattle's water supply. Additional pipelines were added between 1909 and 1954 to meet growing demands for water. Today the Cedar River supplies about 70 percent of SPU's customer demand for water.

In the late 1950s, several King County suburban communities began to look to Seattle as a source of their drinking water. In response, Seattle began selling water wholesale to these communities, who, in turn, supply it to their own customers.

In 1936, the City began developing its water rights on the Tolt River and first put the source to use in 1964. The first phase of the Tolt development was on the South Fork Tolt River, where a reservoir and pipelines were built to increase Seattle's water supply. The South Fork Tolt now provides approximately 30 percent of the City's water supply.

In 1987, the City began development of two well fields near the Highline area, subsequently renamed the "Seattle Well Fields". These well fields are available to supplement Seattle's surface water supplies, especially during the summer peak demand season and emergencies.

1.1.2 System Description

Today, SPU's regional water system is the largest in Washington State. SPU serves more than 628,000 people in its retail service area and provides water to 21 wholesale customers, who together deliver water to an additional population of over 850,000. The water from the Cedar and South Fork Tolt Rivers is treated by ozonation/ultraviolet light and ozonation/filtration respectively. The Seattle Well Fields are available to supplement the South Fork Tolt and Cedar supply sources during peak demand seasons and during emergencies. SPU's water is delivered to Seattle retail service connections and to SPU wholesale customers through a network of approximately 1,800 miles of transmission and distribution system pipelines. Figure 1-1 shows the major components of the Seattle Regional Water Supply System and the areas currently served by SPU and its wholesale customers.

The Cedar River supplies about 70 percent of SPU's customer demand for water, and the South Fork Tolt River supplies about 30 percent.

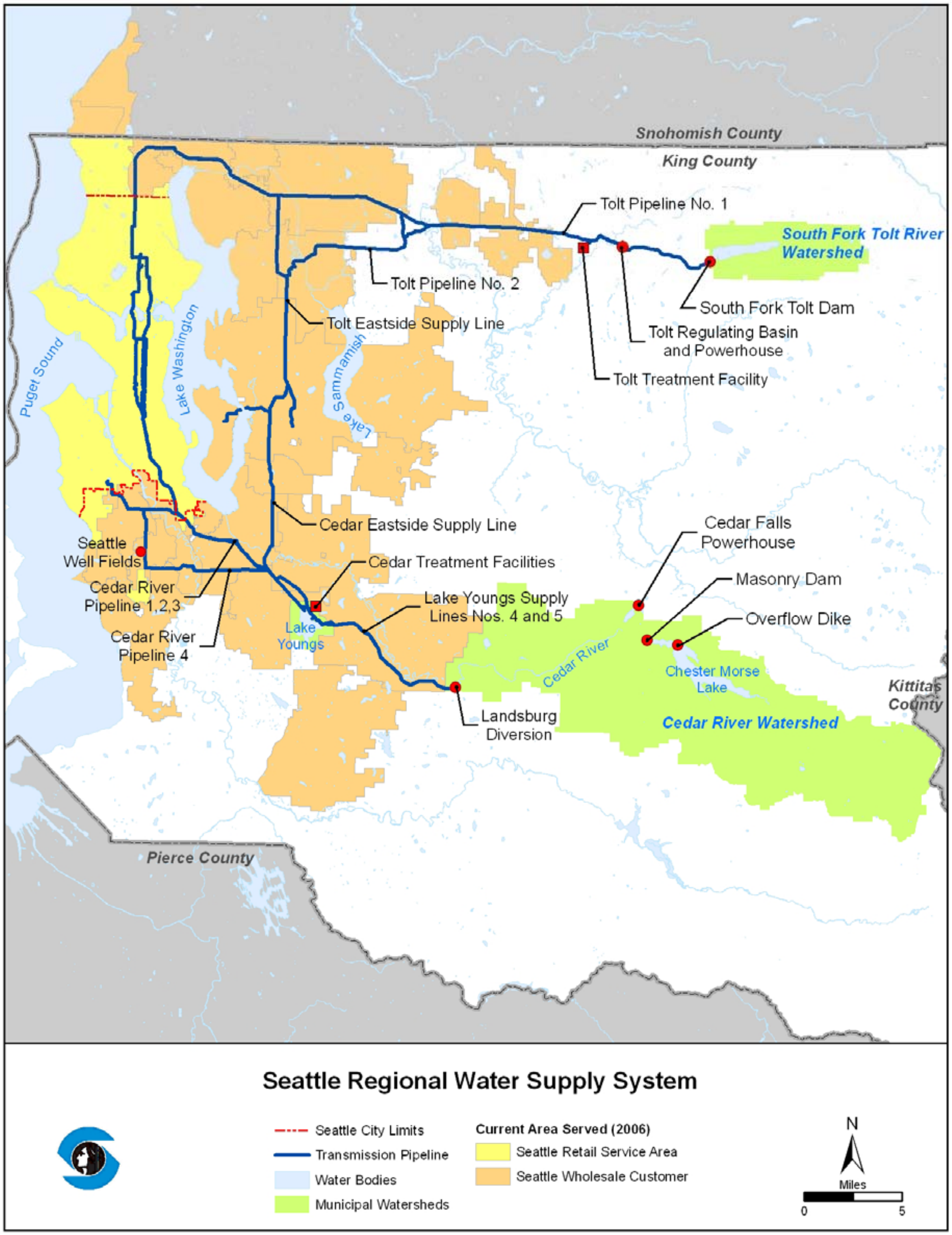


Figure 1-1. Seattle Regional Water Supply System

Since SPU's last *Water System Plan* in 2001, the water utility has added transmission pipelines to provide additional system redundancy and has begun operation of two new source treatment facilities, one for the Cedar supply and one on the South Fork Tolt supply, to meet regulatory requirements, increase reliability and yield, and improve the aesthetic qualities of the water. SPU has also completed new fish ladder and fish passage facilities at the Landsburg diversion dam to restore the historical Chinook and Coho salmon runs to the reach of the Cedar River and tributaries above the dam. In addition, SPU has been actively pursuing its open reservoir covering/replacement program to help maintain the high quality of the treated water that SPU provides.

1.1.3 Business Areas

SPU's water line of business is divided into four business areas: Major Watersheds, Water Resources, Water Quality and Treatment, and Transmission and Distribution.

SPU's water line of business is divided into four business areas that are focused on key components or sub-systems of its water system. By organizing the line of business in this way, SPU is better able to articulate the performance objectives of each sub-system and create accountability in meeting those objectives. These business areas include major watersheds, water resources, water quality and treatment, and transmission and distribution. The mission statement for the water line of business is to provide reliable, high quality water for people and fish.

Major Watersheds Business Area

The Major Watersheds business area covers watershed management of the South Fork Tolt and Cedar River Municipal Watersheds and Lake Youngs Reservation. Activities are conducted to ensure that source water quality and environmental stewardship goals are met. In addition, the Major Watersheds business area includes planning and oversight for watershed land management plans, Cedar River Watershed Habitat Conservation Plan (CRW HCP), Bonneville Power Administration (BPA) settlement agreement implementation, Muckleshoot Indian Tribe agreement implementation, watershed stewardship (including Cedar River Education Center), watershed bridges and roads, watershed protection plans, cultural resources management plans, and other programs and projects involving the watersheds for the surface water supplies. Except for watershed programs and plans to protect drinking water quality (covered in Chapter 3, Water Quality and Treatment), the activities of the Major Watersheds business area are not summarized as part of this *2007 Water System Plan* since such a summary is not required by WDOH.

Water Resources Business Area

The Water Resources business area consists of the programs and projects whose purpose is to plan for and ensure sufficient water is available to meet anticipated demands. One critical function of this business area is real-time management and operation of mountain reservoir and river facilities for water supply, instream resource protection, and flood management, as well as hydropower generation. The programs of the Water Resources business area include instream resource management, water conservation, dam safety, and water rights. The Water Resources business area also performs water supply and demand forecasting, conservation potential assessments, reclaimed water/water reuse analysis, development of new sources of supply when needed, and infrastructure planning for water supplies.

Water Quality and Treatment Business Area

The Water Quality and Treatment business area covers SPU's drinking water quality and treatment programs, projects, services, and capital assets from the source to customer taps. Key functions of this business area include managing SPU's drinking water regulatory compliance, oversight of the Tolt and Cedar water treatment facilities and their contract operations, and overseeing water quality and treatment programs and capital projects. Key water quality monitoring and regulatory compliance services are provided to the Water Quality and Treatment business area by SPU Laboratory Services Division through an internal service agreement. Infrastructure in this business area includes the Tolt and Cedar Treatment Facilities and ancillary facilities, Landsburg treatment and intake screening facilities, and in-town water treatment facilities at reservoirs and well sites. Programs in the Water Resources business area include cross-connection control, storage facility washing, and water main flushing.

Transmission and Distribution Business Area

The Transmission and Distribution business area is comprised of programs and projects affecting the regional and sub-regional transmission systems, which serve both retail and wholesale customers, and the distribution system, which serves only SPU's own retail customers. Business area activities include policy development, planning and oversight for transmission and distribution pipelines, and operation and maintenance of the transmission and distribution pipelines, storage facilities, pump stations, and appurtenances. The Transmission and Distribution business area provides oversight for and coordination with related programs, such as seismic analysis and cathodic protection.

1.2 Corporate Policies that Shape How SPU Does Business

Over the past few years, SPU has been developing and implementing a number of new policies to guide the overall utility operation. SPU has committed itself to using an asset management approach in its decision-making. SPU has also explicitly increased its commitment to environmental stewardship. In addition, SPU has become increasingly aware of the critical need to keep drinking water systems and facilities, and the people who operate them, safe and secure and to ensure that emergency preparedness is a top priority. Finally, since customer service is a key component of how decisions are made in an asset management environment, SPU has committed itself to better communication with its customers to increase its understanding of and its ability to meet their water service needs and expectations. The subsections below summarize new policies that SPU developed in light of each of these commitments. The policies reflect the overall direction for the utility as they apply to the water line of business.

1.2.1 Asset Management Policy

SPU implements asset management as an approach to meet customer service levels at the lowest life-cycle cost.

Since last updating its water system plan, SPU has taken a new approach to planning, maintaining, and investing in its facilities by implementing an approach known as “asset management.” Asset management is an approach to meeting agreed service levels while minimizing life-cycle costs. This approach to making decisions regarding capital projects and operations and maintenance (O&M) work is based on a long-term view of financial, social, and environmental costs and benefits, otherwise known as the “triple bottom line”. Asset management provides the highest long-term value to ratepayers while minimizing life-cycle cost.

SPU is committed to enhancing its capacity to inform the public, interest groups, and decision-makers of policy choices and their trade-offs. SPU embraces the “asset management” framework as a way to define, evaluate and debate the financial, social, and environmental factors from various perspectives before making major project and program investment decisions. Asset management, and the rigor that it offers, provides a transparent and deliberate decision-making process.

This policy articulates the utility’s commitment to asset management as it affects how the utility conducts business and makes decisions in providing high-quality, reliable drinking water for the citizens and businesses of the region for many generations to come.

Policy Statement

Use Asset Management principles to guide all capital and O&M financial decisions to deliver services effectively and efficiently.

1. *Match SPU service levels with customer expectations, and adjust as customer needs change.*
2. *Use the most current methodologies for triple-bottom-line analysis to ensure financial, social, and environmental life-cycle costs, risks and benefits are adequately reflected in capital and O&M decisions.*
3. *Support a transparent and thorough process for considering projects and programs.*
4. *Manage risk by assessing, quantifying in decision making and reviewing alternatives.*
5. *Collect and utilize accurate and timely data which is key to decision-making.*
6. *Continue to seek guidance from world leaders in Asset Management, as well as conduct benchmarking exercises to learn more about best practices and potential organizational improvement.*

1.2.2 Environmental Stewardship Policy

SPU is dedicated to being a leader in protection of the environment.

SPU is committed to operating in a manner that helps protect, enhance, and sustain, over the long-term, the ecosystems that it affects. Over time this commitment has become more prominent in SPU as the environmental ethic of the region has grown stronger. This policy continues SPU's dedication to be a utility leader in protecting the environment as it provides high-quality, reliable drinking water. It is adapted from an SPU policy and procedure developed for guiding all utility business.

Policy Statement

Protect and enhance the environment affected by the utility as it carries out its responsibilities to provide drinking water.

1. *Implement strategies and actions to achieve and exceed the goals and expected outcomes of environmental laws.*
2. *Develop and manage capital and O&M activities, at a minimum, to first avoid and otherwise minimize negative effects to the environment.*
3. *Conduct triple-bottom-line assessment and apply other asset management principles in making decisions about capital and O&M activities aimed at implementing this policy.*

4. *Reflect public and stakeholder interests on key environmental issues in SPU service levels and actions.*
5. *Revise environmental targets and objectives periodically, which include the development of proposed future conditions for important environmental assets, based on scientific learning and practical experience acquired from monitoring environmental performance.*
6. *Monitor SPU's environmental performance through regular evaluations and revise targets and objectives periodically, based on scientific learning and practical experience.*
7. *Reduce the quantity and toxicity of materials used and waste generated from SPU facilities and operations through source reduction, reuse, or recycling.*
8. *Promote and support the efficient use of materials and resources in all phases of a facility's life.*
9. *Promote environmental equity*[1] *through utility operations and programs.*
10. *Assess and manage environmental risks as expressed in SPU's corporate risk and financial management strategies and decision-making processes.*
11. *Engage the public, key stakeholders, citizen owners, and employees in the implementation of SPU's Environmental Performance System, its products, and its improvement over time.*[2]
12. *Lead and work cooperatively with other organizations to promote common regional environmental goals and objectives.*

1.2.3 Security and Emergency Preparedness Policy

SPU continues to increase security measures at its facilities to protect utility operations and maintain water delivery even in the event of an emergency.

SPU has substantially increased security measures to protect utility operations and maintain business continuity. SPU has conducted vulnerability assessments and developed policies to address the three elements of security - operational, physical, and information technology. SPU has also been implementing security

[1] Environmental equity refers to the equitable distribution of environmental costs and benefits geographically across the service area and among various demographic groups.

[2] An Environmental Performance System is an outcome-focused management system that includes: an adopted policy with objectives, actions to achieve the objectives, an environmental audit system, supporting scientific analysis and monitoring, and data storage and results tracking for discrete elements of the system.

improvements at its facilities and has been increasing system monitoring. In addition, SPU has been developing and implementing procedures for an integrated security system that enhances the protection of the entire water system and increases the protection of SPU employees, visitors, and citizens.

In the event that a portion of the water system infrastructure is damaged as the result of a natural or human-caused disaster, SPU has developed an enhanced emergency preparedness program to improve its ability to continue to provide drinking water. This policy is based on SPU's 2003 Charter Security Policy and the detailed security policies that have been developed to guide all utility business at SPU.

Policy Statement

Institute and maintain appropriate safeguards to protect against security risks and sustain emergency response readiness to ensure the continuity of drinking water services, including fire protection service.

1. *Establish a culture where the safety and security of persons, drinking water services, and water system infrastructure, as well as emergency preparedness, are top priorities.*
    a. *Prepare for rapid and effective response to emergencies, whether man-made or natural, accidental or intentional.*
    b. *Provide a safe work environment for employees, contractors, customers, and visitors by incorporating security measures designed to protect people, assets, the environment, and operations against the threat of injury, loss, or damage by criminal, hostile, or malicious acts, including terrorism.*
2. *Maintain an ongoing capability to assess and manage security threats within the limitations of an event or situation.*
3. *Coordinate security policies and programs with other city departments, SPU stakeholders, and other appropriate agencies.*
4. *Incorporate security measures in the development of new and existing SPU water system projects and operations that are positively valued for cost and risk.*

1.2.4 Meeting Customers Expectations Policy

SPU proactively seeks customer input to help determine the service levels that it provides to its customers.

As SPU has embraced asset management, it continues to focus on shaping departmental services to match the needs of both retail and wholesale customers. By fostering better communication with customers and soliciting their input, SPU can more accurately determine the levels of service to provide to customers. This policy articulates how SPU aligns its drinking water services with customer needs and expectations.

Policy Statement

Provide retail and wholesale drinking water service that responds to changing customer expectations centered on providing reliable, high-quality water, and guided by asset management principles.

1. *Use retail and wholesale customer-driven service levels to guide SPU's decisions regarding the drinking water services the department provides.*
   a. *Set service levels that are within SPU control based on high priorities to customers or regulatory requirements.*
   b. *Collect and analyze retail and wholesale customer input through a variety of means, and modify SPU's service level targets as needed.*
2. *Provide services with efficiency and fairness across customer classes (e.g., retail/wholesale, residential/commercial), and across all affected communities.*
3. *Maintain appropriate tools and technology for enhancing customer relationships and responsiveness to customers.*
4. *Explore potential approaches to enhance retail water service beyond the customer's meter, recognizing that SPU's responsibility for water infrastructure ends at the meter.*
5. *Consider expanding fee-based services to wholesale customers and neighboring utilities.*

1.3 SPU's Asset Management Business Framework

For SPU and its customers, asset management is a way of increasing productivity and ensuring cost-effectiveness in service delivery. Asset management is a method of meeting established service levels at the lowest life-cycle cost. Regulatory requirements are also met through asset management. SPU has a number of business procedures in place to incorporate asset management practices throughout its lines of business. These include procedures for establishing service levels, preparation of project development plans for capital projects and programs, development of strategic asset management plans for classes of assets, and benchmarking SPU's performance against other, similarly-sized, water utilities. Each of these procedures is described briefly below.

1.3.1 Service Levels

SPU measures its performance through service levels, or statements of desired performance outcomes.

Service levels are statements of desired performance outcome that are high priority to SPU's customers or required by regulators. Often these service levels go beyond minimum regulatory requirements. Service levels are largely within the control of SPU and have performance level data that can be accurately and consistently collected and audited. SPU utilizes service level objectives – broad statements of intent – to establish the direction of each of its business areas while using service level targets to establish annual or longer term goals which can be measured through performance targets. Service levels are used by SPU to manage its assets, including making decisions on renewal/ replacement and O&M practices. While the current service levels are documented in this *Water System Plan*, they may be revised as new information is gathered from customers and more data is collected on system performance and costs.

1.3.2 Project Development Plans

A project development plan (PDP) is the key document used for evaluating whether a project or expenditure is justified. PDPs are also used for making decisions on programs. The PDP documents project objectives, relevant project data, options, and alternatives, as well as the project work plan with cost estimates and milestones. The business case portion of a PDP includes an analysis of the financial, social, and environmental benefits and costs of a project, a "perspectives" analysis (i.e., who gains and who pays), and an analysis of the risks and uncertainties involved.

1.3.3 Strategic Asset Management Plans

Criticality is a measure of the consequence of failure of an asset.

Strategic asset management plans (SAMPs) are 3- to 5-year planning documents that guide the management of assets to meet defined objectives. Each SAMP covers a class of assets (e.g., pipelines) that represents a major investment by SPU, requires significant resources to maintain, and is important to delivering drinking water service. SAMPs describe relevant assets and service levels, establish criteria for criticality, provide profiles of the assets and known conditions, describe operations and maintenance strategies, provide replacement/renewal capital plans, describe decision tools and models, and identify relevant data that need to be collected and workflow processes that need to be implemented. SAMPs characterize SPU's risk tolerance for the class of asset and define the mitigation of risks associated with ownership and operation of those assets. SAMPs provide more detail on asset classes than a water system plan, are updated more frequently than a water system plan, and centralize information related to the asset.

1.3.4 Benchmarking

SPU participates in benchmarking studies in which it compares its performance with that of other utilities around the world.

SPU's asset management approach makes use of benchmarking–a process whereby a utility measures its performance or process against other utilities' best practices, determines how those utilities achieved their performance levels, and uses the information to improve its own performance. Since 2003, SPU has participated in the benchmarking projects offered by the Water Services Association of Australia (WSAA). These projects allow SPU to compare its asset management processes and its asset costs and service levels with other utilities that are also world leaders in the practice of asset management.

SPU's first benchmarking project with WSAA occurred during 2003-04 and assessed the utility's processes and systems in a variety of areas, such as business planning, asset operations and maintenance, and asset replacement and rehabilitation. In 2005, SPU participated in WSAA's civil maintenance benchmarking project, which reviewed costs and service levels for maintaining water and wastewater pipes and related assets. In 2006, SPU has begun its participation in a mechanical/electrical benchmarking project, which will produce comparative statistics on costs and service levels associated with maintenance of water and wastewater pump stations and treatment plants.

1.4 Current Planning Environment

Since the last water system plan update in 2001, several changes have occurred that help shape the content of this plan. While implementation of an asset management program in itself represents a significant change, other changes include passage of Washington's new Municipal Water Law, new regional relationships, and growing concern about potential impacts of future climate change.

1.4.1 Municipal Water Law

The Municipal Water Law (MWL), passed by the Washington State Legislature in 2003, produced the most sweeping changes to water law in recent years. It provided assurances to utilities for water provision into the future, but it also imposed new requirements. The law significantly impacts the requirements of water system planning. For this reason, all the elements required to meet interim and anticipated regulatory guidelines of the MWL are included in this *2007 Water System Plan*.

Three areas of the MWL generate significant changes from the previous water system plan. The most significant change relates to service area designation. The MWL allows utilities to change the place of use of its water rights to match the utility service area when specific measures of consistency are met. SPU is requesting such a change in this water system plan for its Cedar River and Lake Youngs claims, and this plan documents how consistency requirements are being met.

Another important change is the MWL's requirement for setting a conservation goal. SPU has been a national leader in water conservation and has had quantitative conservation goals since 1996, so this new requirement does not require any new initiative from the utility. It does, however, formalize the process for establishing conservation goals.

The MWL also reinforces the existing requirement that water utilities consider reclaimed water as a water supply option. While SPU's *2001 Water System Plan* contained a discussion of reclaimed water, this plan presents a more thorough analysis of potential, specific reclaimed water projects in its retail service area.

1.4.2 Regional Planning

This *2007 Water System Plan* is a regional plan that addresses the drinking water supply needs of about 70 percent of the population in King County plus a small population in Snohomish County. While the geographical extent of SPU's service area has not changed since the last plan, the relationships among regional water providers have changed.

SPU is committed to working together with other water providers and regional jurisdictions to address water issues.

Over the past few years, SPU has entered into new contracts with most of its wholesale customers that created stronger partnerships with some and created more autonomy for others. Of particular significance since the last water system plan was the formation of the Cascade Water Alliance (Cascade). Cascade has eight utility members, some of whom were once wholesale customers of SPU. Cascade now represents those utilities in the wholesale relationship with SPU.

Due to the nature of the Cascade contract, Cascade, not SPU, now plans to meet the demands of its eight member utilities. The firm block, or fixed amount of water Cascade purchases from SPU, is intended to provide water supply to Cascade members until 2024, after which Cascade anticipates that it will have other sources of supply and will gradually decrease its demand from the Seattle regional system. Cascade is developing its own supply options, including an intertie project with Tacoma, a project in which SPU no longer directly participates.

These new relationships have made regional coordination even more important in efficiently utilizing the region's water resources for people and instream resources. For this reason, SPU is investing significant staff time and sharing its planning tools in coordinated regional planning efforts, like that initiated by King County in 2005 and in the update of the *Central Puget Sound Regional Water Supply Outlook*, being developed by the Central Puget Sound Water Suppliers' Forum. SPU recognizes the importance of coordinating its efforts with other water providers within the region. SPU values information and efficiencies that can be obtained for all regional water users by coordinating with other providers and stakeholders.

1.4.3 Climate Change

Potential impacts from future climate change and year-to-year climate variability have been of increasing concern throughout the world, the country, the state, and locally. In response to this concern, studies are being conducted at all levels and on all aspects of potential impacts to water supply and demand. These studies produce varying results that make forecasts or projections of local impacts imprecise at best. SPU is nonetheless preparing for providing consistent, reliable, long-term water supply to the region even under this uncertainty.

SPU is preparing for the uncertainties and possible impacts of future climate change on the regional water supply system.

SPU has been actively studying the possible impacts of climate change for more than 15 years. Planning efforts to meet future, long-term water demands are described in Chapter 2 of this *2007 Water System Plan*. While current analyses indicate that no new sources of drinking water will be needed to meet retail and wholesale water demand until after 2060, SPU continues to utilize scenario planning as a way to address the uncertainties surrounding how future climate change may impact the region. SPU's analytical capability has been significantly enhanced as the result of its use of a new, sophisticated water supply planning model that has increased SPU's confidence in its decisions. SPU has also developed and used adaptive management strategies to boost the system's operational flexibility and optimize existing supply to be more responsive to year-to-year climate variability.

1.5 PLAN ORGANIZATION

In 2005, SPU reorganized its water utility into the four business areas described previously. This *2007 Water System Plan* has been organized according to those business areas, except that the Major Watersheds business area activities are not required to appear in water system plans and, therefore, do not appear in this plan. The remaining chapters in Part I focus on each of the particular business areas, with Transmission and Distribution handled as separate chapters. Each of those chapters is divided into the following sections:

- A section summarizing the policies that determine direction for the business area. The policy section includes the context for each policy, shifts in policy direction, issues considered in development of the policy, and the policy statement itself.
- A service level section that identifies the service levels for that business area.
- A description of the facilities that business area manages, and the practices it follows in operating and maintaining those facilities. This section focuses on changes since the *2001 Water System Plan*.
- A summary of needs, gaps, and issues that face that business area.
- A summary of the plans and actions the business area will be undertaking or continuing as it moves forward to address the needs, gaps, and issues.

Appendices to this plan are contained in a separate volume as listed in the Table of Contents. The organization of the appendices generally follows the chapters in this volume, and the appendices should be considered part of this *2007 Water System Plan.*

1.6 PLAN AND WAC REQUIREMENTS

Chapter 246-290-100 of the Washington Administrative Code (WAC) requires water purveyors having 1,000 or more services to prepare and submit a water system plan to WDOH. Purveyors must also update that plan every six years. According to the WAC, the purposes of such a plan are to:

- Demonstrate the system's operational, technical, managerial, and financial capability to achieve and maintain compliance with relevant local, state, and federal plans and regulations.
- Demonstrate how the system will address present and future needs in a manner consistent with other relevant plans and local, state, and federal laws, including applicable land use plans.

The contents of a water system plan are governed by WAC 246-290-100(4). Interim guidelines for implementing the MWL have also been used to develop this plan, as available. A checklist provided as an appendix lists the plan contents required by the WAC and identifies the specific chapters or appendices of this plan where that required information can be found.

Chapter 2
Water Resources

Chester Morse Reservoir

SPU's Water Resources business area focuses on the programs and projects that ensure SPU's customers and instream resources will have sufficient water to meet their needs, both in the present and for the foreseeable future. One important function of the business area is the real-time management and operation of mountain reservoir and river facilities for municipal use while meeting instream flow requirements and managing floods. Water resource concerns also include forecasting future water demands and evaluating current supply capacity and the need for future new supply sources and water rights. Future supplies can include traditional sources, such as surface water and groundwater, water "supplied" by conservation efforts, reclaimed water projects, and desalination. The business area also addresses issues related to dam safety and infrastructure maintenance and improvements.

SPU has the water supply necessary to meet needs now and well into the future.

Chapter 2 describes how SPU is prepared to meet water demands in the foreseeable future even with the uncertainties surrounding the potential impacts of future climate change and population growth.

2.1 Policies

SPU has developed water resource policies related to who it serves, its regional role and partnerships, planning for uncertainty, supply reliability, and resource selection. These policies update, revise, or replace policies from the *2001 Water System Plan*.

2.1.1 Service Area Policy

The first priority of SPU's water line of business is to ensure reliable, high-quality drinking water service to its existing retail and wholesale customers while protecting instream resources. From time to time, however, SPU is asked to provide wholesale service to areas that it does not presently serve. SPU continues to be willing to serve new wholesale customers where it is feasible to extend service without compromising its ability to serve existing customers or SPU's commitment and legal obligation to protect instream resources.

This revised policy resulted from the need to clarify what conditions would need to be met for SPU to provide new service.

The policy maintains the same water service area and gives greater flexibility in providing service to new wholesale customers by allowing the City to negotiate the conditions of service individually with each potential wholesale customer. The policy neither over-extends nor revokes any of SPU's commitments and therefore does not increase the utility's exposure to potential risks.

Policy Statement

Continue providing service within the service area boundary as defined in the 2001 Water System Plan*, allowing for new customers within that area at SPU's discretion.*

1. *Consider extending service to new wholesale customers when the following conditions are present:*
   a. *Compliance of the proposed new service with SPU water rights, legal agreements, and any applicable state regulatory constraints.*
   b. *Benefits, or at least has no net adverse impact, to existing retail and wholesale customers based on triple-bottom-line analysis.*
   c. *Compatibility of the proposed new service with the County comprehensive and land use plans.*
   d. *Willingness of the proposed new wholesale customer to enter into a contract with the City that defines the terms and agreements of service.*
2. *Favor service to new wholesale customers where public health is at risk, regional efficiencies exist, or environmental benefits are to be gained.*
3. *Encourage new wholesale providers to participate on the Seattle Water Supply System Operating Board to help guide policy and operational matters as they affect the Seattle regional water supply system.*

The Seattle Water Supply System Operating Board is comprised of wholesale customers and Seattle representatives, and has authorities described in the wholesale water contracts.

2.1.2 Regional Role and Partnerships Policy

Regional growth has spread throughout the central Puget Sound area such that development between Everett and Tacoma is nearly continuous. As a result, the potential and need for regional water planning and interties between neighboring water systems has steadily increased, and utilities have increased coordination to efficiently address both normal and emergency water supply conditions and the potential impacts of climate change. Over the years, SPU has been a leader in regional forums, such as the

Central Puget Sound Water Suppliers' Forum, and active in other regional organizations, such as the regional water associations.

The revised policy on SPU's regional activities reflects the utility's proactive role as both a service provider and regional leader. While collaborative planning may require long time frames and introduce or interject issues from other utilities, the implementation of this policy has a number of benefits that arise from working collaboratively with others. These benefits outweigh the disadvantages since the policy is designed to protect SPU customers when seeking solutions that benefit the region as a whole.

Policy Statement

Be a leader in seeking regional cooperation and efficiencies that benefit the customers of SPU, other water utilities, and the environment.

1. *Continue to engage actively in collaborative drinking water planning efforts that encompass the tri-county area of Snohomish, King, and Pierce counties.*
2. *Manage and operate the water system, under normal and unusual conditions, in coordination with other water utilities, public health agencies, emergency management agencies, flood management agencies, and other appropriate resource agencies in the tri-county area.*
3. *Explore cooperative or conjunctive opportunities with other utilities in the tri-county area that maximize efficiency, drinking water quality, and reliability while being environmentally sensitive.*
4. *Support efforts to ensure availability of drinking water supplies within the region.*
5. *Share knowledge and expertise with other water utilities in the region.*

2.1.3 Planning for Uncertainty Policy

There is significant uncertainty concerning both water supply and water demand that affects how SPU conducts water supply planning. Large shifts in demand can occur, for example, as a result of wholesale customers purchasing more or less water from Seattle than expected. Similarly, changes in legal requirements, such as those resulting from new instream flow requirements, the listing of a new species as threatened or endangered, or an unusually severe drought can affect the water supply available from existing systems. In addition, uncertainties such as potential impacts of future climate change and the time required for source development need to be considered. In the face of uncertainty, SPU has developed a policy that sets the direction for how SPU will plan to meet the long-term water supply needs of its retail and wholesale customers, while meeting the needs of instream resources.

In the past, uncertainty surrounding potential new supplies caused SPU to engage in "parallel planning" of multiple supply and demand management options. While this strategy may have resulted in somewhat higher short-term costs, its goal was to reduce the risk of pursuing a single supply option which might subsequently have ended up being impossible to implement. SPU's new policy has a broader approach than that used in the past to take into account the range of future possibilities that now exists. It incorporates a small part of the old Level of Service policy concerning the timing and sizing of new facilities by attempting to capture how that planning will be done in an uncertain world. This policy allows for the possibility of developing a supply source prior to the cross-over point of supply and demand if an analysis of risk and costs shows this to be sensible. While the policy provides direction for utilizing scenarios to plan for a wide range of possible futures, it carries forward the parallel planning of multiple new sources as has been done in the past.

Policy Statement

Base supply investment strategies on future outlooks for supply and demand that incorporate an evaluation of uncertainties using the best available analytical tools.

1. *Consider investing simultaneously in the planning-level or preliminary engineering design stages of multiple sources to ensure sufficient supply is available to meet demand when it is needed in the future.*
2. *Implement or construct new sources prior to the supply/demand cross-over point when prudent for reducing risk or cost.*
3. *Address potential impacts of long-term climate change on water supply and demand in developing supply investment strategies based on the most current knowledge available and a wide range of climatic conditions.*

4. *Factor in needed emergency reserves when evaluating available water sources and alternative supply investment strategies.*
5. *Re-evaluate the supply investment strategy at least every six years, and adjust it, as needed, based on new information.*

2.1.4 Supply Reliability Policy

Water supply reliability underlies SPU's planning efforts to meet future demand and sets expectations for how dependable the water supply will be under varying hydrologic conditions. This policy reflects how SPU will provide service to its customers and maintain stream flows to protect fish and the ecosystem. The supply reliability policy also provides guidance on the approach the utility will take in meeting water demands during extremely low water supply conditions while ensuring adequate stream flow for fish habitat.

The revised policy reflects the increasing importance of factoring in the water supply needs of fish and reflects SPU's increased emphasis on following the principles of asset management. The policy provides the new direction for incorporating emerging information regarding the ramifications of potential future climate change for drinking water supply. Finally, contingency planning is further defined in this revised policy to reflect the importance of maintaining emergency supplies.

Policy Statement

Plan to meet full water demands of "people and fish" under all but the most extreme or unusual conditions, when demands can only be partially met.

1. *Take into account reductions in demand resulting from demand management when forecasting water demands for people.*
2. *In forecasting water demands for fish, include water that is needed to meet regulatory requirements and provisions of legal agreements, and to maintain healthy ecosystems based on best available science that prove beneficial in a triple-bottom line analysis.*
3. *Use a 98% engineering planning standard for determining long-term yield from water supplies, which differs from the approach used for evaluating available supplies on a year-to-year basis.*

The 98% standard is used to determine the amount of water available in all but the driest 2% of years.

Conjunctive use refers to the combined use of multiple water supply sources to optimize resource use and minimize adverse effects of using a single source.

4. *Include operational requirements associated with flood management, as well as increments in supply related to conjunctive use of SPU supply sources, when determining long-term yield.*
5. *As understanding of regional climate change and variability advances, continue to factor it into long-range demand and supply analysis.*
6. *Maintain a contingency plan that guides utility and customer actions during low water conditions in a way that strives to minimize impacts to people and fish.*
7. *Maintain backup supplies as a tool for managing supply in years with unusually low water conditions.*

2.1.5 Resource Selection Policy

Meeting future water demands for a growing population ultimately involves the selection of specific water resource projects and/or implementing additional conservation. To provide guidance on its resource selection process and criteria, SPU has revised the previous resource selection policy to incorporate asset management principles and selection criteria that were approved by the Seattle Water Supply System Operating Board. This policy reiterates SPU's commitment to sustainable water supply and minimizing environmental impacts while meeting the drinking water needs of future generations. It repeats the previous policy's emphasis that reductions in water use through conservation can be equivalent to increasing supply by the same amount, but also recognizes that conservation may be justified by reasons other than meeting demand, such as meeting legal requirements, environmental stewardship, and customer service expectations. The new policy explicitly includes reclaimed water as an alternative source option and favors regional approaches to water issues, such as implementing conservation on a regional basis and creating interties to more efficiently supply the region with water.

Policy Statement

In planning to meet future customer demand, select new sources of supply from all viable options, including conservation programs, improvements to system efficiencies, use of reclaimed water, and conventional supply sources, based on triple-bottom-line analysis.

1. *Consider conservation programs, pricing, and system efficiency improvements as a way to meet future supply needs in addition to what may be implemented to meet other objectives such as meeting legal requirements, environmental stewardship goals, and customer service expectations.*
    a. *Meet or exceed state requirements for conservation programs and avoid lost opportunities.*
    b. *Evaluate conservation programs using the same method as evaluating other sources of water, where environmental and social benefits are included in the triple-bottom-line analysis.*
2. *Seek opportunities for regional efficiencies.*
3. *Explore reclaimed water projects and evaluate them based on triple-bottom-line analysis in comparison to other source options.*
4. *Assess new supply options using source selection criteria approved by the Seattle Water Supply System Operating Board.*
5. *Select new water supply resources with meaningful public participation.*

2.2 SERVICE LEVELS

In managing its water resources, SPU has established service levels that are consistent with its regulatory requirements and environmental commitments. In particular, SPU's water resources service levels give emphasis to instream flows and conservation. Table 2-1 summarizes these service levels.

Table 2-1. SPU's Service Levels for Managing Water Resources Assets

Service Level Objective	Service Level Target
Meet the environmental requirements of our water rights and water supply operations.	Meet instream flow requirements and performance commitments in tribal, regional, state, and federal agreements and permits.
Meet water use efficiency goals to ensure wise use and demonstrate good stewardship of limited resource.	Achieve water conservation goals: - Save 14.5 mgd (peak season) from 2000 to 2010. - Save additional 15 mgd (average annual) from 2011 to 2030. - Meet the Initiative 63 Settlement Ordinance requirements.

Each service level is discussed in further detail below.

2.2.1 Instream Flow Requirements

In operating its surface water supply sources, SPU is obligated to meet instream flow requirements on the Cedar and South Fork Tolt Rivers to protect fisheries resources and aquatic habitat. On the Cedar River, instream flow management is governed by the Cedar River Instream Flow Agreement (IFA), a component of the Cedar River Watershed Habitat Conservation Plan (HCP). The IFA specifies a guaranteed flow regime as measured at the USGS stream gage below the Landsburg Dam. This regime includes normal and critical minimum flow levels as well as additional supplemental flows or blocks of water at certain times of year that are linked to real-time hydrologic conditions and biological need. The agreement also specifies limitations for changing flow rates (i.e., “down-ramping”) within certain flow ranges, and specifies minimum releases from Chester Morse Lake into a short bypass reach of the river between Masonry Dam and the Seattle City Light Cedar Falls hydroelectric facility. During many times of the year, stream flows exceed the levels required to meet the guaranteed flow regime and municipal diversions. The HCP provides funding for studies to help guide the management of this additional water in collaboration with the interagency Cedar River Instream Flow Commission, which oversees the implementation of the Cedar River instream flow management program.

For the South Fork Tolt River, instream flow requirements are specified in the 1988 South Fork Tolt River Hydroelectric Project Settlement Agreement that was negotiated and committed to as part of the Federal Energy Regulatory Commission (FERC) licensing process for the Seattle City Light South Fork Tolt hydroelectric facility. This agreement specifies normal and critical minimum instream flow levels at the USGS stream gauge on the South Fork Tolt River near Carnation. Limitations on down-ramping flow rates are also included in the agreement. The interagency Tolt Fisheries Advisory Committee oversees the implementation of the instream flow management program and associated mitigation projects.

SPU’s performance in meeting this service level is tracked in semi-annual and annual compliance reports. To date, SPU has almost always met its instream flow obligations; only a few minor noncompliance incidents have occurred, and actions have been taken to prevent reoccurrences.

2.2.2 Water Conservation

SPU is committed to being a leader in water conservation.

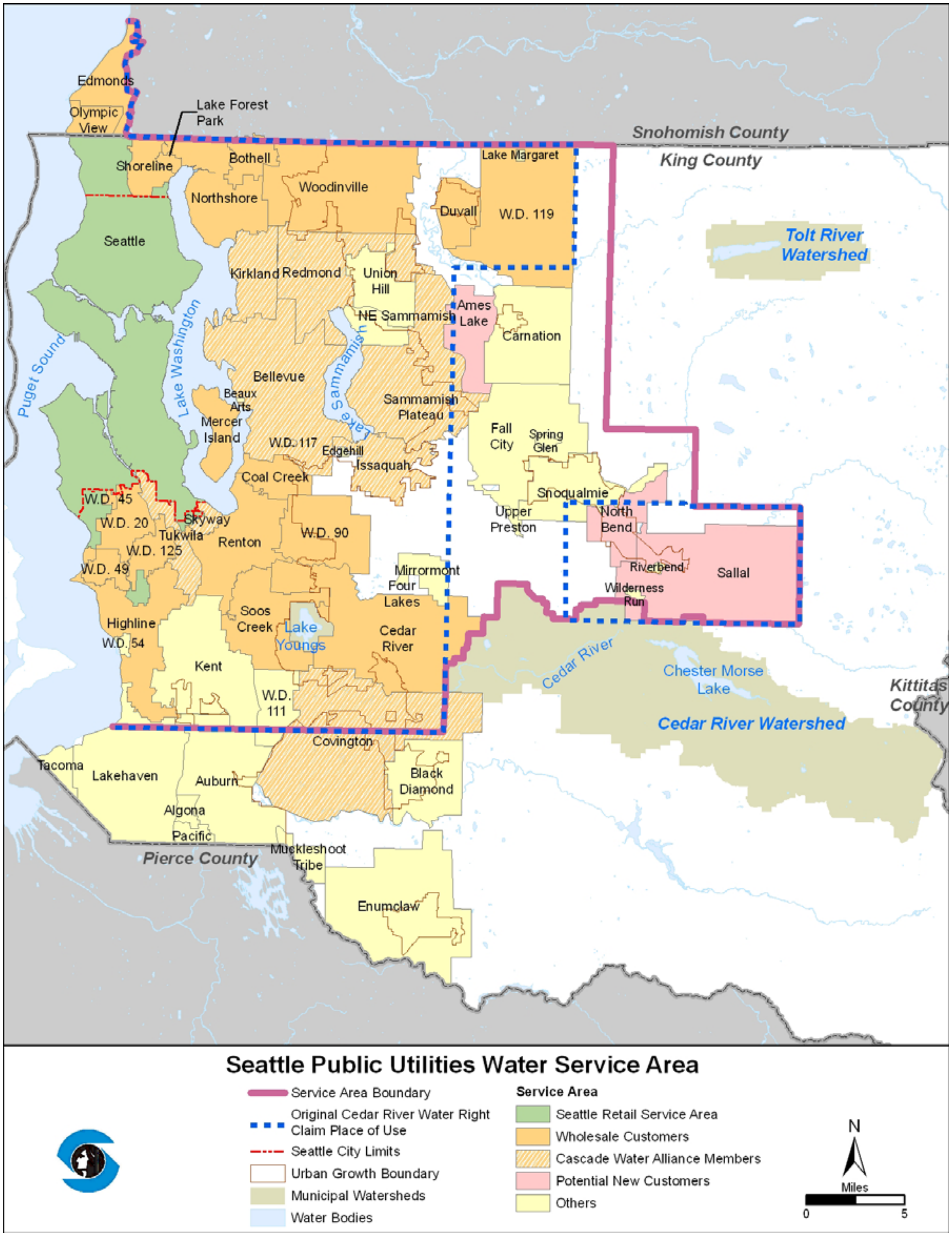
SPU and the Operating Board have made a strong commitment to water conservation. That commitment is reflected in SPU's conservation level of service, which calls for increased efficiency in the use of water over time to ensure wise use and demonstrate good stewardship of limited resources. Specific conservation objectives are tied to City ordinances and conservation programs, discussed later in this chapter. Evaluations of SPU's conservation goals and its performance in meeting them are conducted each year and documented in annual reports. SPU's most recent annual report is included in the Water Conservation Plan 2007-2012 appendix to this plan. To date, SPU is on track to meet its conservation goals.

2.3 Existing System and Practices

The total population living in the area currently served by SPU and its wholesale customers in King and southwest Snohomish County is about 1.45 million. Since some of SPU's wholesale customers have other water supplies, it is estimated that approximately 1.2 million persons use SPU water on a regular basis. To provide water to the people and businesses in its service area, SPU operates and maintains supply facilities associated with its surface water sources and well fields. This section provides an overview of the service area to which SPU provides water service. The section also summarizes the City's water rights and the quantity of water that can be reliably provided to the service area, or the firm yield of its supply sources. SPU's water demands, including the non-revenue component of demand, are then summarized. The City's water conservation programs are described, and the section concludes by describing the operations activities employed to manage instream flows and maintenance activities for the water supply facilities.

2.3.1 Service Area Characteristics

Besides serving retail customers, SPU provides wholesale water to area cities and water districts, who in turn deliver water to their customers' taps. Figure 2-1 shows these different customer types and service area boundaries. SPU's service area maintains the same water service area that has been in place since the *1980 Water Complan*, which, in general, includes the city of Seattle, the suburban areas immediately to the north and south, and similar



* Note: The place of use of the Cedar River water claim is being revised to the entire service area as part of this *2007 Water System Plan*.

Figure 2-1. SPU's Water Service Area*

areas extending east of Lake Washington to slightly beyond North Bend. The population within the Service Area has steadily grown since the *2001 Water System Plan*.

Changes in Demographics

Actual growth in population, number of households, and employment through 2005 has differed from the *2001 Water System Plan* forecast, mostly because of the economic recession in the first half of the decade. Overall, population in the area served by SPU grew at about half the rate forecast in the *2001 Water System Plan*. While employment was projected to increase almost 8 percent between 2000 and 2005, it actually shrank by more than 5 percent over that period. However, after the 2000 census results were released, it became apparent that the year 2000 estimates of population and employment in the *2001 Water System Plan* were too low. Table 2-2 summarizes these demographic changes and compares the current data with forecasts and estimates from the *2001 Water System Plan*.

Table 2-2. Demographic Changes[1]

Year	2001 WSP Data	Current Data	Difference
Population			
2000	1,209,528^E	1,238,645^C	29,117
2005	1,261,870^F	1,267,419^E	5,548
Percent Growth	4.3	2.3	
Households			
2000	523,931^E	524,812^C	881
2005	562,840^F	547,469^E	−15,371
Percent Growth	7.4	4.3	
Employment			
2000	888,750^E	952,618^C	63,862
2005	956,556^F	901,245^E	−55,311
Percent Growth	7.6	−5.4	

Data sources: C=2000 Census data; E=Estimate; F=Forecast

1 Population data from the *2001 Water System Plan* did not include Covington Water District, Issaquah, and Sammamish Plateau. Also excluded from the *2001 Water System Plan* population data were Edmonds, Lake Forest Park, and Renton, all of which purchase only negligible amounts of water from SPU. For comparison purposes, the data above also exclude these areas.

Retail Customers

SPU delivers water directly to a population of more than 628,000 through more than 180,000 service connections, approximately 32,000 more people than indicated in the *2001 Water System Plan*. This increase has resulted from increased population density from development of vacant property and redevelopment of property to higher densities. Since the *2001 Water System Plan*, significant redevelopment has occurred in the City's six urban centers. The area between the north end of downtown and the south tip of Lake Union has been largely rezoned as "Seattle mixed," which allows for residential and commercial development. South Lake Union was designated as Seattle's sixth urban center in 2004.

Wholesale Customers

SPU's wholesale customers currently serve a total population of more than 850,000; about 600,000 of the people living in these areas actually use water from SPU on a regular basis. Non-SPU water is supplied to the other 250,000 customers by these wholesale customers. Current Seattle wholesale customers, listed in Table 2-3, include 21 municipalities and special purpose districts.

Table 2-3. SPU Wholesale Water Customers

Name of Customer	
Bothell, City of	Renton, City of[2]
Cascade Water Alliance (Cascade)[1]	Shoreline Water District[3]
Cedar River Water and Sewer District[3]	Soos Creek Water and Sewer District[3]
Coal Creek Utility District[3]	Water District No. 20[3]
Duvall, City of	Water District No. 45[3]
Edmonds, City of[2]	Water District No. 49
Highline Water District[3]	Water District No. 90
Lake Forest Park Water District[2]	Water District No.119
Mercer Island, City of[3]	Water District No.125[3]
Northshore Utility District[3]	Woodinville Water District[3]
Olympic View Water and Sewer District[3]	

1 Individual members of the Cascade Water Alliance are the cities of Bellevue, Issaquah, Kirkland, Redmond, and Tukwila, and Covington Water District, Sammamish Plateau Water and Sewer District, and Skyway Water and Sewer District.

2 Purchases negligible amounts of water from SPU.

3 Represented by Seattle Water Supply System Operating Board.

The wholesale customers' service areas have experienced more rapid population growth than SPU's retail service area. The significant growth in the number of persons served by SPU wholesale customers reflects the region's continued development of previously undeveloped land. Development occurring in the commercial, high technology, industrial, multifamily, and supporting governmental and institutional sectors has also had an impact. This is particularly true in the more established areas of Bellevue, Redmond, Renton, Kirkland, and southwest King County, where the population and employment densities have become more similar to that of Seattle.

Since 2001, SPU and most of its wholesale customers have signed new wholesale water contracts to replace the 1982 contracts that were to expire on December 31, 2011. SPU now provides service to its wholesale customers under three contract types:

- Full Requirements Contracts. Since 2001, SPU has negotiated and is implementing long-term, full-requirements water supply contracts with nine of its wholesale customers. These new contracts extend to 2060, establish wholesale water rates, and include a provision for an operating board to address issues related to the Seattle water supply system. The wholesale customers also have the first right of refusal for contract renewal after the 60-year contract ends.

- Partial Requirements Contracts. SPU has also signed new partial-requirements contracts with two of its wholesale customers, Highline Water District and Olympic View Water and Sewer District. These utilities have their own sources of supply with which they meet a portion of their demand, depending on Seattle for the rest. Contract provisions pertaining to expiration dates, wholesale rates, Operating Board membership, etc., are identical to the full requirements contracts.

- Block Contracts. In 2003, SPU signed long-term contracts for specified amounts of water ("block contracts") with the Cascade Water Alliance (Cascade), whose members are listed above in a footnote to Table 2-3, and Northshore Utility District. SPU's contract with Cascade is a declining block contract that limits annual Cascade purchases from SPU to an average 30.3 million gallons per day (mgd) through 2023, after which the block volume begins to decline. The block will be reduced by 5 mgd in 2024 and by another 5 mgd in 2030. Additional 5-mgd reductions will occur every 5 years thereafter through 2045, leaving a final block of 5.3 mgd. As a new, independent wholesaler of water, Cascade chose to not participate on the Operating Board.

  Northshore's block contract is for 8.55 mgd on an average annual basis for the duration of the contract, which is expected to meet all the district's water supply needs. Northshore provides water directly to its retail customers and participates on the Operating Board.

2.3.2 Water Demand

Since 1990, water consumption has steadily declined despite population growth.

For most of Seattle's history, water consumption increased along with its population. However, that link was broken around 1990 when consumption reached its highest level. Since then, water consumption has steadily declined due to various forms of conservation despite continued population growth. By 2005, consumption was lower than it had been since 1964.

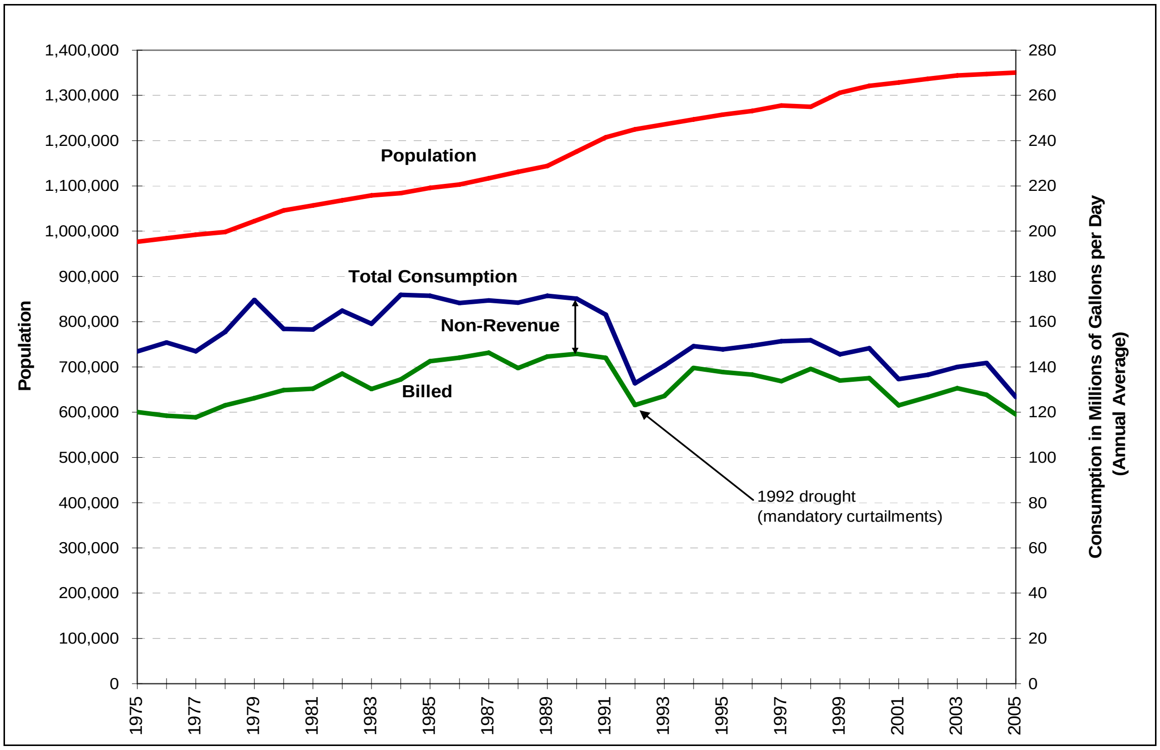
Historical Water Consumption

Figure 2-2 displays Seattle system water consumption and population since 1975. While population has steadily risen since 1975, water demand leveled off during the 1980s before dropping off sharply in 1992 due to a severe drought and mandatory curtailment measures. Since then, the combined effects of higher water rates, the 1993 state plumbing code, conservation programs, and improved system operations kept both billed and total consumption significantly below pre-drought levels. Water consumption has further declined in the last 5 years due to additional conservation efforts represented by the regional 1% Conservation Program, significant increases in water and sewer rates[1], and an economic slow-down. Since 1990, consumption has decreased about 40 mgd (24 percent) while population increased by 13 percent.

Peak water demand has fallen even more than annual average demand since the 1980s. In the 1980s, hot summer weather could produce peak day consumption of over 325 mgd. However, during an extremely hot summer in 1994 when temperatures reached 100 degrees, peak day consumption was only 270 mgd. Ten years later, peak day consumption barely reached 250 mgd during the two very hot, dry summers of 2003 and 2004. Peak month consumption has also been trending downwards over the past twenty plus years, though not as steeply as peak day consumption.

Before the 1992 drought, peak month consumption averaged over 250 mgd. Since then, the average has been around 205 mgd.

[1] Seattle's sewer rates are based, in part, on water use, so that using less water may result in a lower sewer bill, thereby increasing a retail customer's incentive to conserve water.



*Note: Issaquah, Sammamish Plateau, and Covington Water District are not included in historic data because they did not become customers until 2004 when contract with Cascade was signed.

Figure 2-2. Population Growth and Water Consumption from SPU Sources, 1975–2005*

Non-Revenue Water

Non-revenue water is calculated by subtracting total metered water sales - both retail and wholesale - from total water diversions from SPU's water supply sources.

SPU's system non-revenue water is calculated by subtracting total metered water sales, both retail and wholesale, from total water diversions. Decades ago, Seattle had a considerable amount of non-revenue water. Between 1975 and 1984, non-revenue water averaged about 30 mgd, almost 20 percent of total water consumption. In 1985, Seattle began taking steps to reduce the amount of non-revenue water used in operating the system. The in-city reservoirs with the highest leakage rates were relined and the amount of water used for flushing Green Lake was decreased. Average non-revenue water dropped to 26 mgd (representing 15 percent of total water consumption) over the period 1985-1990. More efficient in-town reservoir washing practices and the elimination of in-town reservoir overflows related to turbine use brought non-revenue water down even further in 1991. Finally, the 1992 drought prompted additional changes in practices. Green Lake flushing and reservoir overflowing were completely eliminated, while reservoir improvements, such as joint sealing and relining, continued to be made. As a result, non-revenue water was reduced to just 10 mgd, or 7 percent of total consumption.

Since 1992, non-revenue water has remained relatively flat, fluctuating mostly between 10 and 13 mgd and averaging 11 mgd or about 8 percent of total consumption. Some in-town reservoir overflowing was resumed in 1996 for water quality reasons with episodes of significant overflowing taking place in 1997 and 2004. SPU has installed drain line meters on two of its four remaining open reservoirs to measure the quantity of overflowing water. As the remaining open reservoirs are covered or replaced, overflowing will be substantially reduced, as will the need to empty the reservoirs for cleaning. Table 2-4 reflects SPU's best current estimates of the components of non-revenue water.

Table 2-4. Components of Non-Revenue Water and Estimated Magnitudes

Total Non Revenue Water	10.0 mgd
System Operations	2.0 mgd
Reservoir Overflowing	1.0 mgd
Reservoir Draining/Cleaning	1.0 mgd
Water Main Flushing	<0.1 mgd
Public Uses	0.3 mgd
Construction	<0.1 mgd
Sewer flushing, fire fighting, street-cleaning, etc.	0.2 mgd
Meter Inaccuracies[1]	3.4 mgd
System Losses	4.3 mgd
Measured Losses (Reservoir Leaks/ Evaporation)	0.3 mgd
Unmeasured Losses (Pipeline Leaks and Other)[2]	4.0 mgd

[1] All the above categories except meter inaccuracies were estimated by water service and operations staff. Meter inaccuracies were calculated by subtracting the estimates for all other types of non-revenue water from total non-revenue water. To the extent the estimates for all other types of non-revenue water are (on average) too low, the estimate of unmeasured losses will be too high, and vice versa.

[2] Based on recent theoretical analysis of system leak rates. See Distribution System Renewal Strategy Technical Memorandum, March 2006, in the Appendices.

2.3.3 Water Conservation Programs

Low flow appliances help conserve water

The City is currently pursuing two ongoing programs or initiatives to encourage conservation both regionally and locally:

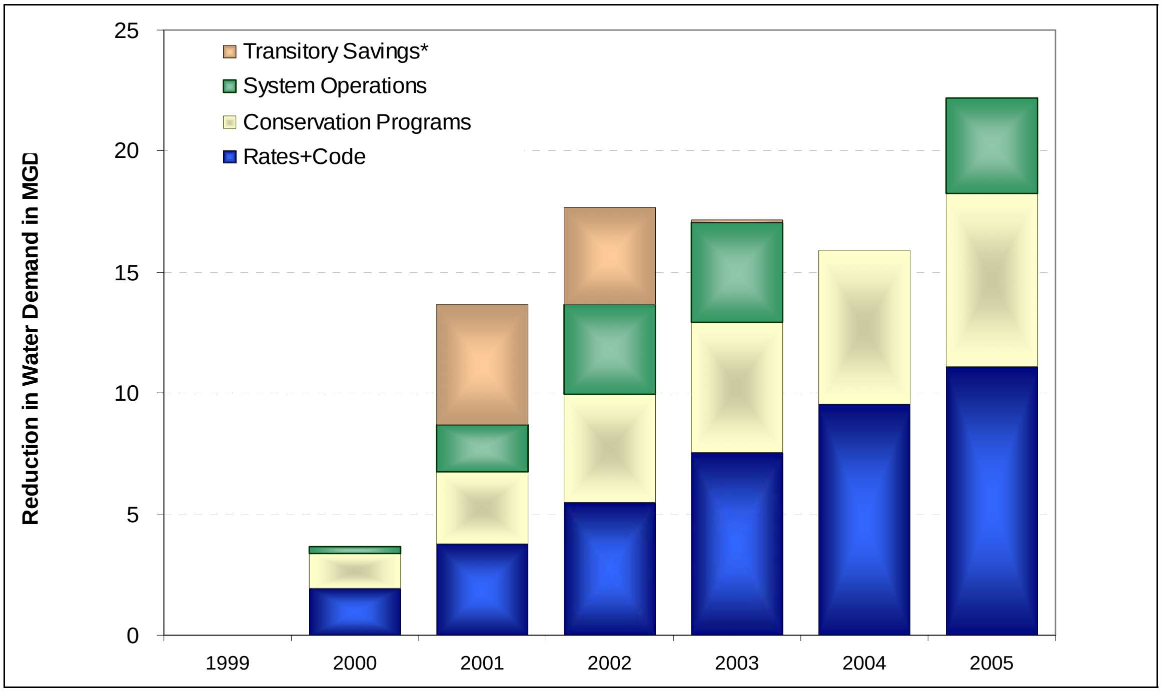
- 1999 1% Regional Water Conservation Program (1% Program)
- Initiative 63 Settlement Ordinance (I-63 SO)

The motivation for the City's 1% Program was the 1997 demand forecast that predicted that without conservation, Seattle would need a new source of supply by 2013. The long-term goal was to keep water demand flat through 2010 despite 10 years of forecasted population growth. The 1% Program was expanded to include the entire SPU service region in 2000 and is sponsored by the Saving Water Partnership, which includes Seattle and most of Seattle's wholesale customers. Performance targets for the 1% Program from 2000-2010 include reducing annual per capita consumption by 1 percent per year and achieving a cumulative total of 14.5 mgd peak season savings, or approximately 11 mgd on an annual basis. The 1% Program plan is included in the Water Conservation Plan 2007-2012 appendix to this plan.

The City of Seattle adopted the I-63 SO in 2001 (Ordinance 120653), which committed the City to pursue conservation beyond the 1% Program in the SPU direct service area and to focus on low-income housing conservation assistance by establishing the Everyone Can Conserve Program. From 2001 through 2005, that program saved an estimated 0.4 mgd of annual average water savings by retrofitting a total of 14,087 housing units with water conservation fixtures and equipment. The I-63 SO directed SPU to provide 3 mgd of water savings in the Seattle retail service area above and beyond the 1% Program by 2010. The I-63 SO is being implemented through the Everyone Can Conserve Program, through increased system efficiencies resulting from the accelerated in-town reservoir replacement program, and other cost-effective measures.

Between 1999 and 2005, an estimated cumulative average annual savings of 22 mgd was achieved.

Figure 2-3 shows cumulative water savings from various sources, including the 1% Program, I-63 SO, efficiencies in system operations, changes to the plumbing code, pricing, and transitory savings. Between 1999 and 2005, an estimated cumulative average annual savings of 22 mgd was achieved.



*Note: Transitory savings are water reductions from drought curtailments and carry-overs in subsequent years.

Figure 2-3. Cumulative Water Savings from Conservation, in Average Annual mgd, 1999-2005

2.3.4 Infrastructure

To meet the water demand of its customers, SPU operates and maintains two surface water sources of supply, each of which has associated infrastructure (such as reservoirs, dams, pump stations, and pipelines). This section describes the capacities of each of Seattle's water sources and provides information concerning the City's water rights and firm yield. The 2006 agreement between the City and the Muckleshoot Indian Tribe is also discussed.

Supply Sources

Seattle obtains approximately 70 percent of its raw drinking water supply from the Cedar River and most of the remaining 30 percent from the South Fork Tolt River, as described in the *2001 Water System Plan*. Seattle's two well fields are available to provide peak season and emergency supply. Additional information about each supply source is included below. The Cedar Supply is discussed at greater length because of its greater complexity.

Cedar River. The Cedar River Municipal Watershed is located in the Cascade Range within southeast King County. The watershed contains the 1,680-acre Chester Morse Lake, formed behind a Masonry Dam. The lake serves as a reservoir for 15.8 billion gallons (48,500 acre-feet) of high-quality water above its natural gravity outlet.

The Chester Morse Lake pumping plants, two sets of barge-mounted pumps, each with the capacity to pump 120 mgd, are stationed year-round on the lake and can be anchored near its outlet to draw additional water from below the outlet level during drought emergencies. The pumping plants can also augment the gravity flow capacity of the outlet channel during normal supply conditions. Changes to the pumping facilities, outlet channel, and associated discharge dike have been made since 2002 to restore flow capacity and improve reliability of the system.

Water stored in Chester Morse Lake flows downstream to the Landsburg Diversion Dam and fish passage facility, which is located about 14 miles downstream from the Masonry Dam. Here, water is diverted through pipelines to Lake Youngs Reservoir. Lake Youngs Reservoir, with a useable storage capacity of approximately 1.5 billion gallons (4,600 acre-feet), provides additional storage and regulates flows to the Cedar Treatment Facility.

Some of the Cedar River source water is lost from the Masonry Pool, the portion of the reservoir between the Overflow Dike and Masonry Dam, via seepage into a moraine on the Pool's northern bank. Water leaks out of the Masonry Pool mostly in the spring and early summer, when water is relatively abundant, fills an underground "reservoir" or aquifer, then returns to the river in the summer, when it provides a water supply benefit in the critical fall season in the extreme dry years. About 75 percent of the water that leaks from Masonry Pool is "stored" in this way and finds its way back to the Cedar River, while the remainder ends up in the Snoqualmie River basin. The system is operated to minimize the impacts of this seepage loss.

South Fork Tolt River. The South Fork Tolt River Municipal Watershed is located about 13 miles east of Duvall in King County. The South Fork Tolt Reservoir, which went online in 1964, provides 18.3 billion gallons (56,160 acre-feet) of storage. Water from this reservoir is conveyed to the Tolt regulating basin and the Tolt Treatment Facility.

The Seattle Well Fields can be artificially recharged to increase production.

Seattle Well Fields. In addition to the major surface water supplies, Seattle operates two small well fields in the City of SeaTac to provide additional peak season capacity and emergency supply, as needed. The Riverton well field has two wells, and the Boulevard Park well field has one well. In total, the three wells can supply up to 10 mgd for approximately four months. The well fields are naturally recharged, but the wells can also be artificially recharged using a method known as aquifer storage and recovery (ASR), if needed. When used, ASR injects treated water from the Cedar River into the production wells to supplement natural recharge into the aquifer.

Water Rights

Seattle holds various water rights for use of water from the Cedar River, South Fork Tolt River, and Seattle Well Fields. Also, Seattle has water right applications on file with the Washington State Department of Ecology (Ecology) for potential future sources of supply, including for the North Fork Tolt River, Snoqualmie Aquifer, and additional yield from the Seattle Well Fields. An evaluation of specific Seattle water right claims, permits, and applications as called for in Washington State Department of Health (WDOH) planning guidelines is included as an appendix to this *2007 Water System Plan*. Forecasts indicate that Seattle does not need to apply for any new water rights within the 20-year planning horizon.

In 2003, the Municipal Water Law (MWL) was enacted, which allows the place of use for a municipal water right to be changed to coincide with the service area described in the municipal supplier's most recently approved water system plan. Through this water system plan, SPU seeks to change the place of use for the Cedar River and Lake Youngs water right claims to the service area described in this plan, as allowed by this provision of the MWL and as shown in Figure 2-1.

Other significant events regarding water rights have occurred since the *2001 Water System Plan*:

- Ecology granted a certificate for the South Fork Tolt Reservoir on January 17, 2003, which finalizes Seattle's right to store water at the reservoir.

- Seattle applied for a reservoir permit in June 2005 for the ASR project at its two well fields and permits for use of the wells to replace its temporary permits.

- Ecology granted a 27-year extension to the City's diversion permit for the South Fork Tolt River on November 30, 2005.

Firm Yield and Supply Reliability

The firm yield of SPU's current supplies is 171 mgd.

Firm yield is the amount of water that SPU is able to supply system-wide at a given delivery pattern while meeting the supply reliability standard, instream flow requirements, and other system constraints. Firm yield is expressed as an average annual delivery rate in mgd from all sources operated conjunctively. Calculating firm yield for SPU's existing supply sources is critical to ensuring that SPU can meet existing and future demands reliably. The firm yield can be compared to long-term forecasts of water demand to determine when new sources or additional conservation programs need to be online to maintain the desired level of supply reliability. Firm yield calculations are also useful in determining the quantity of water that can be expected from a potential new source of supply.

SPU uses a computer simulation model to calculate the firm yield from its existing water supply sources and potential new water sources. This model is known as the Conjunctive Use Evaluation (CUE) model. The model is used with 76 years of reconstructed historic flow records to produce a system-wide firm yield estimate. SPU's supply reliability standard is 98 percent. Therefore, SPU's firm yield is the amount of water that is assured for delivery in all but the driest 2 percent of years without lowering reservoirs below normal minimum operating levels. The combined firm yield of all SPU supplies is 171 mgd, the same as it was in 2001.

Agreement with Muckleshoot Indian Tribe

In 2000, the City completed the Cedar River Watershed HCP and was granted federal incidental take permits for its water management, hydropower, and land management operations. In 2003, the Muckleshoot Indian Tribe (Tribe) legally challenged the permits and HCP on the grounds that they did not assure sufficient water for fish. In 2006, the City and Tribe reached a legal settlement that addresses Cedar River instream flows and water diversions and also addresses other issues of mutual interest, including past damages to fish runs and access to the municipal watershed. That settlement establishes greater certainty for the region's water supply, supports Tribal treaty rights, strengthens fish protection, and creates a cooperative framework for resolving issues in the future.

Aspects of the agreement that are particularly important to SPU's water resources management include the following:

- Guaranteed instream flows. Whether or not the 50-year HCP continues in force, the City will continue to fulfill all of its commitments in the HCP related to instream flows and related research in perpetuity.

The Muckleshoot Agreement preserves SPU's firm yield while ensuring that sufficient water will be available for instream resources in the Cedar River.

- Limits on Cedar River diversions. There are interim limits, leading to permanent limits, on average annual water diversions to provide certainty that the Cedar River will not be over-appropriated to the detriment of instream resources while preserving SPU's firm yield.
- Transfer of water right. Seattle will transfer the portion of its perfected water right claim that exceeds the permanent annual average diversion limit of 124 mgd to the State Water Trust for the purpose of protecting instream flows.
- Continuing water conservation. Seattle will continue its conservation efforts and include a requirement to implement conservation measures similar to those required of Seattle retail customers in all new wholesale contracts.

Other elements of the settlement agreement address Cedar River sockeye salmon mitigation and Tribal fishery projects; Tribal access to the municipal watershed for hunting, gathering, wildlife management and research, and conducting traditional activities there; a cooperative plan for wildlife management; a 10-year wildlife research program; and transfer of land to the Tribe.

2.3.5 Operations

The surface water supply facilities on the South Fork Tolt and Cedar Rivers are operated primarily for water supply and instream flows, but are also used for hydroelectric power generation and flood management. The reservoirs are drawn down and refilled each year. The groundwater supply facilities at the Seattle Well Fields supplement these sources, if needed. Water resource management and operations have changed since 2001 as a result of SPU's installation of a fish ladder and fish passage facilities at the Landsburg Diversion Dam. SPU has also been experimenting with operational techniques to better manage water temperatures for fish. These operational changes are discussed below, following a brief discussion of how SPU manages seepage from the Masonry Pool to benefit both fish and people.

Controlling Masonry Pool Seepage

As noted previously, some of the Cedar River source water can be lost as a result of seepage through the porous soils of the Cedar moraine on the northern bank of Masonry Pool. This seepage actually provides an overall net benefit to water supply because of the additional storage provided by the moraine aquifer and the timing of water returning to the Cedar River. Recent analysis conducted by SPU found that if seepage from Masonry Pool were completely eliminated, an estimated 24 mgd of firm yield would be lost. Presently, water levels in the lake and pool are managed to minimize moraine embankment instability and the potential loss in water supply yield. These management practices are focused on manipulating the water surface elevation in the Masonry Pool to selectively manage seepage to the moraine. Without these efforts to manage seepage, modeling suggests that SPU's firm yield would be as low as 133 mgd, compared to SPU's actual firm yield of 171 mgd.

Operational Changes Due to Fish Passage

The *2001 Water System Plan* described SPU's efforts to reestablish native salmon populations above the Landsburg Diversion Dam (excluding sockeye salmon given their large numbers and the resulting potential for drinking water quality impacts) as part of Seattle's commitments established by the Cedar River Watershed HCP. SPU began operating its new fish ladder and fish passage facilities on the Cedar River in late summer of 2003, just prior to the return of adult salmon. The HCP also provides for an enhancement of raw water quality monitoring activities to verify previous investigations that projected little or no effects on drinking water quality from passing limited numbers of Coho and Chinook salmon upstream of Landsburg.

The operation of the downstream fish passage facility can affect river flow rates downstream of Landsburg Diversion Dam. Landsburg facility operators are integrating their operating procedures to meet instream flow requirements and river flow management objectives under varying hydrologic and water supply conditions.

Temperature Management at South Fork Tolt Reservoir

Since 2004, SPU has been experimenting with operating the existing reservoir intake gates to draw water for release from different water depths in the South Fork Tolt Reservoir in order to establish whether water quality, especially water temperature, in the South Fork Tolt River downstream of the South Fork Tolt Dam can be improved to benefit instream resources. SPU is continuing to monitor and collect data for analysis.

2.3.6 Maintenance

SPU's water resource maintenance activities focus on the City's watershed dams and particularly on dam safety. The water system includes seven dams located in the Cedar and Tolt water supply systems that are owned by SPU. These dams are maintained to ensure operability and safeguard against damage or failure in large floods, earthquakes, malevolent acts, and general deterioration from aging. The Dam Safety Section of the Washington State Department of Ecology (Ecology) and FERC regulate the maintenance of SPU's dams to ensure continued safe performance. Both Ecology and FERC require regular inspections of these dams and related infrastructure, such as spillway gates and dam failure warning systems; inspections that can result in requirements for maintenance work or major capital improvements.

SPU is developing a strategic asset management plan (SAMP) for the major dams that are part of the water supply system. This SAMP will analyze how SPU should maintain and repair the dams and make recommendations as to any renewals of the existing dams or their components. It will also include recommendations regarding elements such as the mechanical and electrical equipment associated with the dams, including the dam failure warning systems.

2.4 NEEDS, GAPS, AND ISSUES

Needs, gaps, and issues facing the Water Resources business area include the need to appropriately plan for water supply in the face of uncertainty, the need to ensure consistency with other related planning efforts, the need to improve water supply infrastructure, the issue of the optimal operating range of the South Fork Tolt Reservoir, and the lack of a supply management service level. Each of these specific needs, gaps, and issues is discussed in the following section, along with how SPU plans to address them.

2.4.1 Planning for Uncertainty

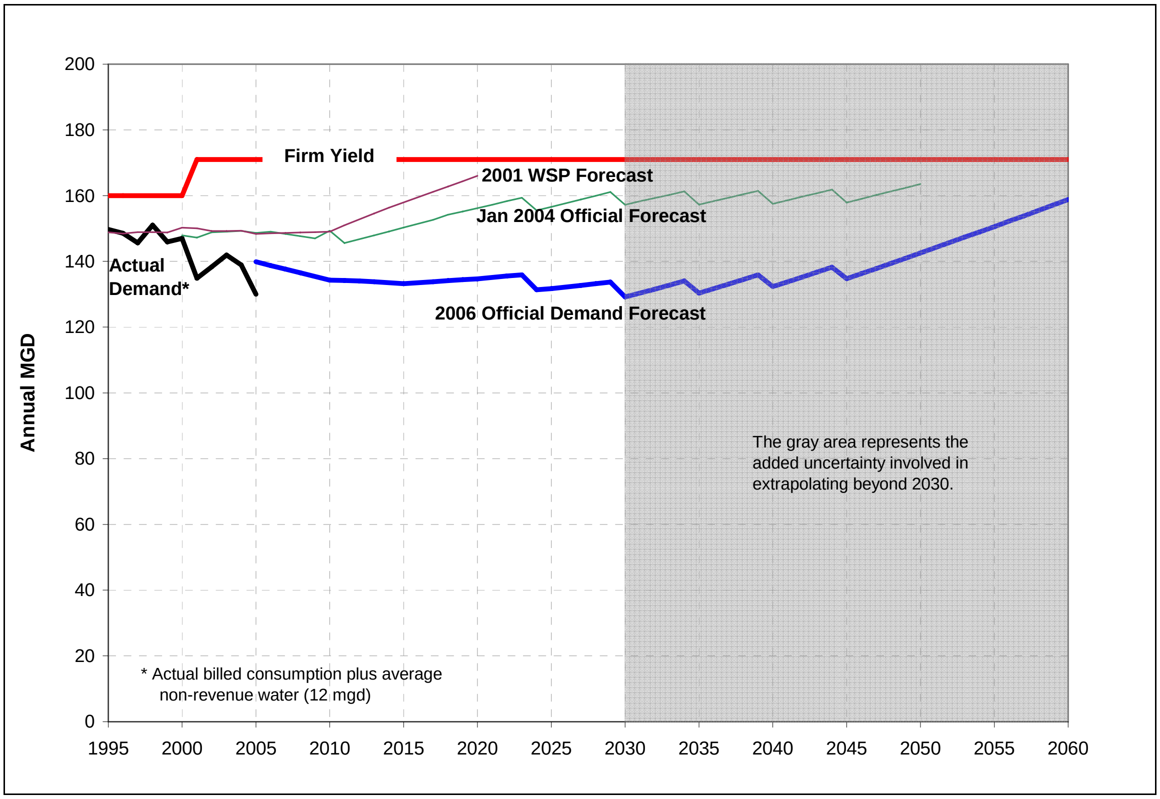
The uncertainties affecting both future water demand and future water supply are considerable. Future water demand is dependent on population growth, income, conservation, climate, weather, and other factors, such as changes in water appliance efficiency standards. Future water supply depends on climate, legal and regulatory issues, the feasibility of developing new supplies as needed, and other factors, such as operational changes and improved system optimization. SPU has developed water demand forecasts and analyzed future water supply alternatives using frameworks that incorporate these relative uncertainties. The results of SPU's analyses are described in the following sections.

Forecasting Water Demand

Long-term water demand forecasting is critical for water system planning. SPU has developed a Demand Forecast Model that incorporates the best features of various model types found in applicable literature. Like simple "fixed flow factor" models, the new SPU model is easy to understand and has relatively modest data requirements. However, like more complex econometric models, the model reflects the impacts of variables such as price, income, and conservation on water use factors over time. This approach takes advantage of past econometric analysis to provide estimates of how price and income can affect demand. SPU's Conservation Potential Assessment (CPA) Model is used to estimate the impacts of plumbing code and programmatic conservation on the water use factors over time.

No new sources of supply will be needed until after 2060 given the firm yield estimate and the official demand forecast.

SPU's official water demand forecast is presented in Figure 2-4. In the official forecast, total water demand is projected to remain essentially flat over the next 40 years. There are two primary reasons for this. One is the impact of conservation programs planned through 2030, and the other is the 5 mgd supply reductions in the Cascade block that will occur every 5 years between 2024 and 2045. Once the Cascade block has been reduced to its minimum level in 2045, and with the assumption of no additional conservation programs after 2030, the water demand forecast begins rising again, finally reaching current levels by about 2050, and 159 mgd by 2060. Peak demands are also forecasted to remain below historic high levels. Given the current firm yield estimate for SPU's existing supply resources and the official demand forecast, a new source of supply will not be needed until sometime after 2060.



* Note: The increase in firm yield in 2001 is due to the start-up of the Tolt Treatment Facility.

Figure 2-4. SPU's Official Water Demand Forecast

SPU's official water demand forecast is based on a number of assumptions in five key areas:

- <u>Future Conservation Goals and Programs.</u> For many years, SPU has been implementing conservation as a way of extending supplies to meet demand. SPU recognizes, however, that there are numerous other factors that drive the need for conservation programs. After completing an analysis to determine the most reasonable level of investment based on all the drivers for conservation programs, the Operating Board selected a conservation goal of 15 mgd of cumulative savings from 2011 through 2030. These savings are included in the demand forecast as a baseline of savings from conservation. If more water is needed in the future, additional conservation programs would be considered as a way to meet future needs, as indicated in the resource selection policy at the beginning of this chapter.

The 2011-2030 Regional Conservation Program may include both public education to promote behavioral changes and customer incentives for installing water-efficient equipment to promote conservation. The conservation goal includes price-induced water savings from rates.

Table 2-5 shows SPU's water conservation goals for the 6-year water system plan period from 2007 through 2012. These savings include those anticipated from the current regional 1% Program, I-63 SO requirements, and the first two years of the 2011-2030 Regional Conservation Program. The Water Conservation Plan described in the appendix contains an analysis used to set the conservation goal and information related to existing and future programs.

Table 2-5. Water Conservation Goals and Other Savings, Average Annual Savings, in mgd

	2007	2008	2009	2010	2011	2012
Programmatic Conservation Goals						
1% Regional Program	1.12	1.12	1.12	1.12		
Seattle Ordinance 120532 (I-63 SO)[1]	0.63	0.63	0.63	0.63	---	---
2011-2030 Regional Baseline Conservation Program	---	---	---	---	0.75	0.75
Total Conservation Goal	1.75	1.75	1.75	1.75	0.75	0.75
Other Savings						
Plumbing Code	0.69	0.66	0.64	0.62	0.60	0.58
Price Savings[2]	0.20	0.20	0.20	0.20	---	---
Total Other	0.89	0.86	0.84	0.82	0.60	0.58
Total Estimated Savings	2.63	2.61	2.59	2.57	1.35	1.33

1 Savings are from SPU's direct service area and include the "Everyone Can Conserve" program, reclaimed water projects, reservoir covering and other system efficiencies, and conservation investments in City of Seattle facilities.

2 After 2010, included in 2011-2030 Regional Conservation Program savings goal.

- Block Contracts. The block supply amounts to be provided by SPU to Northshore and Cascade are included in the forecast as stated in the contracts. Under the Cascade contract, Seattle will provide a fixed block of 30.3 mgd to Cascade through 2023. The block will be reduced by 5 mgd in 2024 and by another 5 mgd in 2030. Additional 5 mgd reductions will occur every 5 years thereafter through 2045, leaving a final block of 5.3 mgd. This has been incorporated into the new forecast, resulting in the "saw tooth" shape.

- Potential New Wholesale Customers. As part of this planning effort, SPU contacted other utilities in its service area to determine if there are potential new customers that may turn to Seattle to meet their future demands. Three utilities indicated interest in being included in SPU's planning: the City of North Bend, the Sallal Water Association, and Ames Lake Water Association. SPU has been actively working with North Bend and Sallal to develop a way to meet their water supply needs while protecting instream resources. Demands for these two purveyors and Ames Lake are included in the SPU demand forecast.

- New Wholesale Contracts. While most of SPU's wholesale customer agreements are in effect until 2062, eight utilities remain under 1982 contracts that expire December 31, 2011. These eight wholesale customers include the Cities of Bothell, Edmonds, Duvall, and Renton, Water Districts 49, 90, and 119, and Lake Forest Park Water District. SPU intends to continue to provide wholesale water to these agencies as needed and will negotiate terms and conditions for new wholesale agreements based on their needs while protecting the interests of other SPU customers. Some of the key issues that would be discussed in the development of new contracts include: (1) contract term, (2) water quantity, (3) costs of water and transmission, (4) conditions of service, (5) roles and responsibilities related to ensuring water quality standards are met, (6) participation in conservation programs, (7) roles related to planning and emergency response, and (8) participation on the Seattle Water Supply System Operating Board. If agreements cannot be reached prior to the expiration of the current contracts, SPU will continue to supply water to those agencies at a rate SPU considers appropriate for the level of service and certainty provided.

The Environmental Block is water dedicated to environmental benefits for salmon.

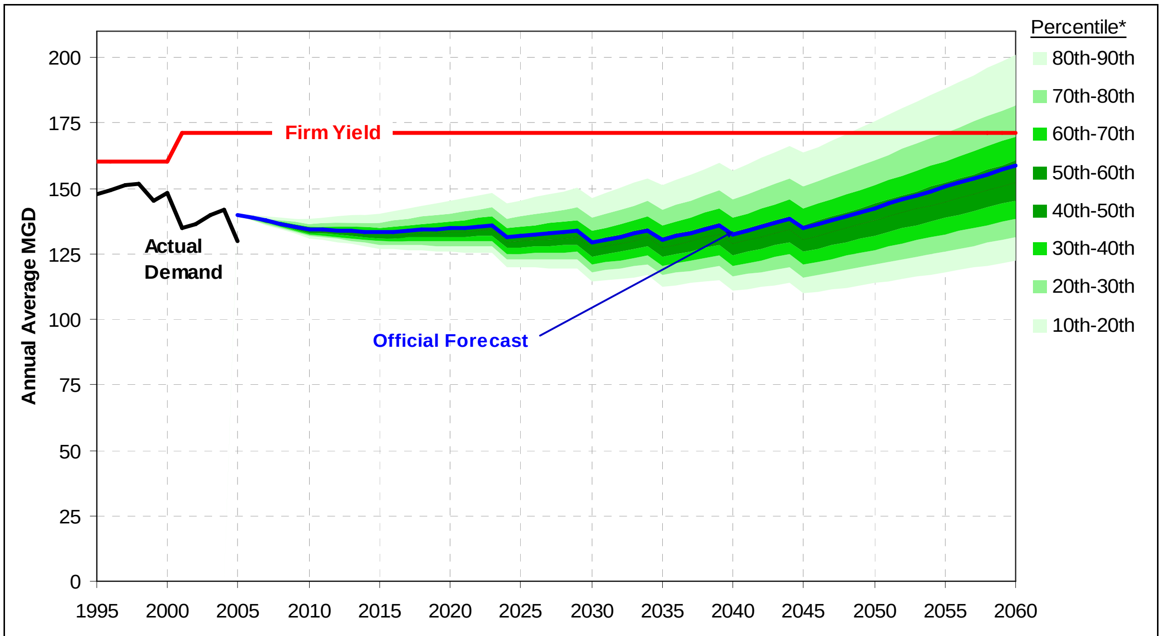
- Environmental Block. Unlike the 2004 official demand forecast, the set-asides for the Environmental Block are *not* included as a component of water demand in the current forecast. The Environmental Block, as defined in the I-63 Settlement Ordinance, is water dedicated to environmental benefits for salmon that increases over time from 2 mgd in 2001 to as much as 12 mgd in 2015. This commitment will now be met through the 2006 agreement with the Muckleshoot Indian Tribe, in which the City has agreed to leave 20 mgd of its perfected water right in the Cedar River.

- Non-Revenue Water. Combined transmission and Seattle distribution system non-revenue water is assumed to decrease from 12 mgd to 9 mgd between 2000 and 2015 as in-city reservoirs are covered. From that point on, however, non-revenue water is projected to gradually increase, reaching 15.5 mgd by 2060. This increase is expected to be caused by the increasing number of leaks that are likely to occur as the distribution system ages.

Uncertainty in Demand Forecast. Forecasting future water demand with certainty is virtually impossible. The official water demand forecast is based on forecasts of income, water prices, households, and employment, all of which are subject to uncertainty. Additional uncertainty surrounds the forecast model's assumptions about price elasticity, income elasticity, and future conservation (the model assumes no programmatic conservation past 2030). These uncertainties were modeled by estimating probability distributions for each source of uncertainty. These distributions became inputs to an aggregate uncertainty model employing a Monte Carlo simulation[2] to characterize uncertainty associated with the official demand forecast.

The results of the Monte Carlo simulation are displayed in Figure 2-5. The green bands indicate the range of uncertainty associated with the official forecast. Each band represents a 10 percent increase (from the band immediately below it) in the probability that actual demand will be equal to or less than the level shown. For example, the bottom of the lowest band represents the 10th percentile, meaning that there is an estimated 10 percent chance that actual demand will be at or below that level (i.e., 122 mgd in 2060) and, thus, a 90 percent chance it will be above. The top of the uppermost band is the 90th percentile, corresponding to an estimated 90 percent probability that actual demand will be at or below that level (i.e., 201 mgd in 2060).

[2] A Monte Carlo simulation calculates multiple scenarios of a model by repeatedly sampling values from the probability distributions for the uncertain variables. The data generated from the simulation can be represented as probability distributions or confidence intervals. Because the method is based on random chance, it was named after the city of Monte Carlo which is known for its gambling.



* Note: Percentiles represent the probability that actual demand will be less than the value shown. Ranges reflect uncertainty in projected household, employment, price and income growth, price elasticity, income elasticity, and conservation. Note that the official forecast is at about the 57th percentile.

Figure 2-5. Uncertainty in Water Demand Forecast*

This type of analysis provides insight into the uncertainty that surrounds the various inputs to the demand forecast model. It estimates a 70 percent probability that a new source will not be necessary before 2060 given the range of uncertainty in demand that was tested. The uncertainty analysis also implies a 90 percent probability that existing sources will be sufficient to meet demand through at least 2048.

SPU also considers the uncertainty of discrete events that produce significant and sometimes abrupt changes in customer demand. Assigning a probability of occurrence to these events is difficult. These uncertainties are examined through scenario planning in which the outcome of those events occurring is considered. For example, a change in federal washing machine standards could be adopted that would cause a drop in demand. Another example is an increase in demand could occur if a wholesale customer's own source of supply is less than forecasted. SPU monitors such developments so that adjustments to the forecast can be made when appropriate.

Future Supply Outlook and Climate Change

For planning purposes, SPU uses current estimated firm yield to make decisions about when new supply sources may be needed in the future. Yet, like demand, there are events that could affect firm yield in the future, both positively and negatively. These events include regulatory changes such as the FERC re-licensing of the South Fork Tolt hydroelectric facility, operational changes, or future droughts more severe than any on record. While these can not be quantified at this time, SPU considers their potential impact in scenario planning as more is learned about how they may affect firm yield.

SPU incorporates available information on the potential effects of climate change into its water supply planning.

Climate change is another uncertainty that SPU must consider in ensuring that future water demands for people and fish are met. Through scenario planning, SPU can use available information on climate change in planning for adequate water supply while ensuring that decisions do not result in unnecessary or premature financial and environmental costs for the region. Adaptation can also provide SPU with system resiliency and flexibility that can better prepare SPU to meet water demands for people and fish as the impacts of climate change and variability are felt in the region. SPU remains engaged in research to identify potential impacts and system vulnerabilities.

SPU Involvement in Climate Change Research. SPU's involvement in the water supply impacts of climate change began in the late 1980s, when its Chief Engineer was actively engaged in the development of the American Society of Civil Engineer's policy on global climate change. This involvement continued during the 1990s as SPU engineers engaged with climate change experts on various research projects. In 2002, SPU contracted with the University of Washington Climate Impacts Group (UW-CIG) to conduct a study on the potential impacts of climate change and to develop methods for how SPU could incorporate future climate change into its water supply planning process. SPU continues its collaboration with UW-CIG by sponsoring additional research on potential impacts on water supply from climate change in partnership with the Cascade Water Alliance, Washington State Department of Ecology, and King County. SPU's commitment to identifying and preparing for potential impacts from climate change was also profiled in *Climate Change and Water Resources: A Primer for Municipal Water Providers*, which was developed by the National Center for Atmospheric Research (NCAR) and the

American Water Works Association Research Foundation (AwwaRF).[3]

Potential Climate Change Impacts. The SPU-sponsored study by UW-CIG has produced the best available information on climate change related to SPU's water supplies. While the study is still under review, SPU and UW-CIG have jointly developed a set of conclusions that describe the method UW-CIG used to translate information from global models to the local watershed scale, the uncertainty associated with this method and results, and the potential impacts produced by this method on different attributes that affect water supply. SPU has utilized these conclusions to consider potential impacts on water supply from climate change. The methodology and conclusions are summarized below.

The study used a series of loosely linked models to translate potential future climate change scenarios to the local watershed level. The method provides a modular approach for creating localized climate change scenarios for water planners that are consistent with the IPCC greenhouse gas emissions scenarios[4]. In the study, considerable effort was devoted to selecting for evaluation the most highly respected global circulation models and testing to determine how well they could reproduce local conditions. In this study, the models used consisted of:

- Global Climate Models. Four general circulation models (GCMs) run with the SRES A2 emissions scenario[5], which produced a range of results. Outputs from the GCMs were not assigned unqualified occurrence probabilities and are, therefore, treated as possible scenarios.

- Downscaling Approach. Statistical downscaling to the local watershed level and timescale appropriate for hydrologic modeling at the local watershed level.

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[3] Kathleen Miller and David Yates, National Center for Atmospheric Research, 2006.

[4] The Intergovernmental Panel on Climate Change (IPCC) developed a set of "storylines" and scenarios for differing social, economic and demographic developments in the future and the resulting greenhouse gases emissions.

[5] A2 is described as "…a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines." (http://www.grida.no/climate/ipcc_tar/wg1/029.htm)

- Hydrology Model. Watershed hydrology models to produce inflows to appropriate portions of the Tolt and Cedar River watersheds.

- Water System Model. Systems simulation model to estimate supply from Seattle's existing sources. The measure of system yield used in this study is slightly different from that used by SPU to estimate firm yield. In addition, the model assumed static management and operation of the supply system (for instance, fixed reservoir operating rules) and did not attempt to quantify the impacts from adjustments in operations and management.

As computer model performance, modeling assumptions and scientific information change over time, this method allows for those individual models and assumptions in the chain of models to be replaced with the new ones to perform methodical and incremental climate change analysis updates as desired. The methods used in this study are data and computationally intensive and such updates would not be trivial efforts.

Among the models used, the greatest individual modeling uncertainty and limitation can be attributed to the GCM running the IPCC emissions scenarios. The next largest is the statistical downscaling method, which is used to correct GCM biases as well as translate GCM low resolution spatial and temporal scales down to high resolution spatial and temporal scales required for the hydrology models at the local watershed level. Hydrologic modeling produces the third largest contribution of uncertainty. There is significant cumulative modeling uncertainty associated with this method, and the range of this uncertainty is equal to the range of natural variability seen in the observational historic record. Nevertheless, the modeling results are useful for water supply planning purposes and for re-examining existing and planned water management systems under a wider range of climatic conditions. It is important to note that climate change is an evolving science, and in the decades to come, evaluation approaches and our ability to characterize impacts will improve. Thus, the results that follow must be viewed as the best estimate possible at this time.

The model results averaged from four different GCMs all run with the IPCC SRES A2 emissions scenario, each statistically downscaled to the Cedar and Tolt watershed level, are summarized below:

- Air Temperature. The average modeled results for nine meteorological stations in the Puget Sound Regions show an increase in average annual air temperature in each subsequent decade into the future. Compared to the reconstructed historic average over the 1930 to 2000 time period, the models produced an average increase of 1.4 degree F and 2.3 degrees F in 2020 and 2040, respectively.

- Precipitation. The averaged model results for nine meteorological stations in the Puget Sound region show nearly normal total annual precipitation volumes in each subsequent decade into the future. The deviations in total precipitation derived from the downscaled GCM data do not range significantly outside the span of natural variability.

- Snowpack. The averaged model results show that the combined average annual maximum snow water equivalent in the Cedar and Tolt watersheds could decrease by as much as 50 percent by 2040 relative to the 1928 to 1998 reconstructed historic norm, due primarily to the warmer air temperature produced by the models. The averaged model results show that unusually low snowpack years could be more frequent in the future. For example, a 1-in-50 year event can become a 1-in-5 year event.

- Hydrology. The hydrology of Seattle's water supply watersheds is expected to change over the next fifty years due to both natural and anthropogenic causes.

- Combined Inflows. The averaged model results show an average decrease in combined inflow volumes to the Cedar and Tolt reservoirs during the period June 1 through September 30 of about 6 percent per decade through 2040, which totals to about 5,000 acre-feet by 2040, when compared to the reconstructed historic record for the 1928 to 1998 time period.

- Impacts on Yield. The averaged model results show a trend that indicates a potential decrease in available water over the next 40 to 50 years, assuming static management of the system with no operational adjustments. The averaged modeled rate of change of gross yield for the current Seattle water supply system is a decline on the order of 6 mgd, or 3.4 percent, per decade through the mid-21st century. The spread in each decade's estimate shows the lack of strong agreement between climate models, a measure of uncertainty in the future.

Climate Change Scenario. SPU is able to create scenarios to examine potential impacts on decisions about future supply using the results from this study. This can be done in two ways: scenario planning and sensitivity analysis in the Water Supply Planning Model, which is described in the next section.

While the modeled impacts on yield are described as a trend, reductions in yield occur abruptly due to the occurrence of a drought that is more severe than that experienced in the past. With future climate change, the likelihood of a significant reduction in yield is expected to increase in the future, and the magnitude of this reduction is projected to increase in coming decades, assuming operational adjustments are not made.

Using the average results from the UW-CIG study, SPU created a climate change scenario utilizing two time periods, 2020 and 2040, and the potential yield reductions for each time period, assuming static management of the system with no operational adjustments.

- Climate Change Scenario - 2020: In 2020 the study projects a reduction in yield of approximately 12 mgd, to 159 mgd. If this were to occur, there would be no impact on SPU's ability to meet its projected demands in 2020 even when considering the range of uncertainty around demand described in previous sections.

- Climate Change Scenario – 2040: In 2040 the study projects a reduction in yield of approximately 24 mgd, to 147 mgd. If this were to occur existing sources would still be sufficient to meet the official demand forecast through 2053, assuming no further decrease in yield after 2040. SPU's analysis of demand uncertainty estimates an 80 percent probability that demand will not yet have reached 147 mgd by 2040.

As information about climate change is refined, it will be considered through this type of analysis so that timely, environmentally sensitive, and cost-effective supply decisions can be made. SPU anticipates doing this at least every 6 years in conjunction with the Water Supply Plan update, or sooner if new significant information comes available.

Adaptation Strategies for Climate Change. Results from the UW-CIG study help SPU to better understand the extent and type of impact that could occur in the future as a result of climate change. Because of decreasing per capita consumption, the declining block contract with the Cascade Water Alliance and operational changes that better utilize existing sources, no new sources of supply may be necessary for SPU's service area for the next few decades. The study does help SPU to focus on the type of adaptation that would best prepare the supply system for those potential impacts. Planning for the uncertainties that climate change will create involves continued research on the potential impacts of climate change and the use of adaptation strategies for the supply system.

How SPU manages and operates the water system on a day-to-day basis can be revised to provide greater flexibility.

Over the years SPU has created and applied a series of adaptation strategies to enhance the water supply system while providing protection to important aquatic species. Some of these techniques involve making changes in how SPU operates the system to be more responsive to the variability of climate while others involve investments in infrastructure to increase the reliability of critical facilities and the resiliency of the overall system. These strategies not only help in managing the system for the variations in weather that now occur, but can be used in the future to adjust to further climate change.

How SPU manages and operates the system on a day-to-day basis can be modified to provide greater flexibility. SPU uses a dynamic reservoir elevation rule curve to help guide the management of flood storage capacity and refill of its mountain reservoirs. This approach adjusts reservoir level targets based on real-time snowpack measurements and soil moisture conditions. This information, coupled with simulation models, helps to set reservoir targets during the refill season. The dynamic rule curve is more adaptive than the fixed rule curve assumed in the UW-CIG study.

The operational flexibility that can be provided by utilizing the dynamic rule curve is demonstrated by SPU's experience during the winter of 2005. Low snow pack in the winter reduced the probability of floods from snow melt. Due to this reduced probability of flooding, SPU water managers captured more water in storage earlier than normal. This adaptation of operations to weather conditions provided Seattle with enough water to return to normal supply conditions by early summer, despite the lowest snowpack on record. It also demonstrated the flexibility in the water system to adjust operations for changing weather conditions, whether they are low snowpack or abnormal levels of precipitation.

SPU is also engaged in an operations and optimization study to identify changes that could be made to add flexibility to the system and optimize use of the Cedar and Tolt sources. One component of this effort is the South Fork Tolt Reservoir Studies described in section 2.4.4 of this chapter, which would explore changes to how that source is operated. Another component is the Cedar/Tolt

Transfer Improvements study, described in the Water Transmission Chapter, to provide greater flexibility in using water from each source.

The 2011-2030 Regional Baseline Conservation Program, which is described earlier in this chapter, is also insurance for managing future climate change. Maintaining this base level of conservation and the programs and staff that support it retains the capability to augment conservation efforts in those years when SPU and its customers need to reduce demands. Although there is no programmatic conservation included in the demand forecast after 2030, SPU assumes that some will be conducted and added to the forecast when more is known about the extent of possible savings. This will provide continued insurance for managing climate change beyond 2030.

In addition to adaptation strategies, SPU has identified elsewhere in this document capital infrastructure investments it can make to improve SPU's ability to respond to climate change and variability. Examples of these investments are the Chester Morse Lake pumping plant improvements and those to be identified through the Cedar/Tolt Transfer Improvements and the South Fork Tolt Reservoir studies.

Future Analysis. Building on past research and other work, SPU will expand its knowledge of the evolving science behind climate change by continuing to partner with leading scientists. This research will help to further refine SPU's understanding of the local impacts of climate change and provide an increased understanding of how our system can adapt over time. SPU will be engaging in research that could include the following areas:

- Flood Event Frequency. Potential impacts of climate change on flood event frequency would be useful for evaluating alternative operating strategies for the future. Different methods or modification of the methods used in this study would be required for this type of evaluation.

- Fall Rains. A key vulnerability to the Seattle water supply system is the timing and intensity of fall rains, and any changes due to climate change would be important to understand.

- Water Demand. How climate change may affect summer weather patterns, and thereby water use during the summer irrigation season, would be another key area for exploration.

- Developing Hydroclimatic Reconstructions. This work would involve using tree ring samples to reconstruct past hydroclimatic conditions and would use the reconstructed conditions to conduct an assessment of how vulnerable the system may be to significant climate variability.

- Additional Scenarios. Similar analyses incorporating different and updated greenhouse gas emissions scenarios would be important to understanding the potential impact on water supplies and demands. Other scenarios to be explored include worse-case drought scenarios, including extreme droughts not yet experienced on record.

- Other Downscaling Methods. The UW-CIG study used statistical methods for downscaling GCM data to the local watershed level. Physical modeling methods are also available and may have the potential to better capture the unique physical characteristics of the region that influence local weather.

- Effects of Changes in Operations. This would involve quantifying the impacts from changes in operations in order to determine how much additional flexibility is gained from operational improvements.

Evaluating Supply Alternatives

SPU uses its Water Supply Planning Model to look at alternative future supply strategies and incorporates asset management principles. This model was used to look at traditional sources of supply, water conservation, reclaimed water projects, and to a lesser level of detail, desalination. The following paragraphs describe the water supply planning model, the alternatives evaluated, evaluation results, and the recommendations from the model.

Water Supply Planning Model Description. With SPU's focus on asset management and in recognition of the uncertainties surrounding future supplies and demand, SPU created a modeling framework to explore water supply strategies[6]. The framework allows SPU to make supply investment decisions based on lowest life-cycle costs while considering risks and the triple bottom line. This model consists of two components:

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[6] *SPU Water Supply Planning Model*, April 2006, prepared for Seattle Public Utilities by CH2M HILL.

- Decision Tree Model. The decision tree model computes levelized unit costs in current dollars of different supply investment strategies based on various uncertainties and scenarios. The strategies consider the source to be developed and when it would come on line. This model is used to explore source development uncertainties, loss of supply due to legal/regulatory changes, climate change and variability impacts, and cost uncertainties.

- Value Model. The value model merges the source selection criteria approved by the Operating Board with the SPU risk assessment framework to create a tool for evaluating the non-monetary values, benefits, and impacts associated with supply options, including conservation packages. Each supply alternative is scored for public/political acceptability, environmental impacts, legal/regulatory issues, public health/drinking water quality, social/lifestyle impacts, ease of development, and operational reliability and robustness. These scores are then weighted to produce a single value score.

The results of both models are considered in selecting a supply strategy.

Evaluation of Traditional Supply Sources. Traditional supply alternatives were evaluated using the Water Supply Planning Model. The additional supply and cost estimates for these supply alternatives, which were presented in the *2001 Water System Plan,* are summarized in Table 2-6.

Evaluation of Reclaimed Water Projects as a Supply Source. Five studies have been performed in recent years by Seattle or King County to investigate the costs and benefits of using reclaimed water as an additional source of supply. As part of this *2007 Water System Plan,* SPU evaluated in more detail the most promising potential reclaimed water projects in Seattle's retail service area that had been identified in the previous studies. The alternative evaluation, included as an appendix, looked at the quantity of water that each alternative project could produce, the benefits or value of implementing the project, and the costs of producing the reclaimed water. The results of that evaluation indicate that the unit cost of the water obtained from these reclaimed water projects are significantly higher than the cost of obtaining additional water from more traditional sources.

Table 2-6. Summary of Traditional Supply Alternatives

Alternative	Description	Additional Firm Yield	Design and construction cost (in millions)	Annual fixed operating cost (in thousands)
Chester Morse Lake Dead Storage	Construction of a pump station to access dead storage to 1502' on a more regular basis as a part of normal supply.	20-39 mgd[1]	$26.2	$341
Lake Youngs Drawdown	Use of storage at Lake Youngs and additional diversions from Cedar River to increase firm yield. Addition of filtration at Cedar Treatment Facilities.	20 mgd[1]	$164.2	$2,236
Additional South Fork Tolt Reservoir Drawdown	Drawdown of reservoir to different elevations depending on temperature and turbidity restraints. May require changes at Tolt Treatment Facility.	4 mgd (1695') 8 mgd (1660')	$0.31 (1695') $19.3 (1660')	$146 (1695') $496 (1660')
North Fork Tolt River Diversion	Construction of a small diversion on the North Fork Tolt in addition to drawdown of the South Fork Tolt to elevation 1660' and installation of Tolt Treatment Facility sedimentation basins.	8-40 mgd[2]	$179.3	$2,267
Snoqualmie Aquifer	Development of the Snoqualmie Aquifer with new filtration plant, pump station, and an interconnection to SPU's Tolt pipeline.	16 mgd[3]	$114.9	$1,860

1 Conceptually, a portion of this additional water supply could be used to augment instream flows on the Cedar River.

2 Depends on instream flow requirements on the main stem of the Tolt River.

3 Assumes all of firm yield addition is available to SPU.

In addition to the high unit costs for the reclaimed water projects, runoff from the golf course irrigation alternatives could potentially flow towards salmon-bearing streams, thereby raising environmental concerns and requiring evaluation and monitoring to ensure environmental and human health safety per Resolution 30454 adopted by the City of Seattle in 2002, unless replaced by successor legislation. Environmental concerns were factored into the value score for these projects. A summary of the results of the reclaimed water evaluation are shown in Table 2-7.

The *Draft White Paper, Reclaimed Water Backbone Project, Version 3.0* (March 2006, King County Department of Natural Resources and Parks, Wastewater Division) identified twelve potential customers for reclaimed water in the City of Shoreline service area from the Brightwater Reclaimed Water Phase III Conveyance System. The City of Shoreline, where residents west of Interstate 5 are SPU retail customers, currently has no specific plans to implement any of those reclaimed water projects. SPU will rely on the City of Shoreline to initiate further investigation of any reclaimed water opportunities within its city limits.

Table 2-7. Summary of Reclaimed Water Project Alternatives

Alternative	Description	Average Additional Supply	Construction cost (in millions)	Annual operating cost (in thousands)
Catholic Calvary Cemetery	Construction of a membrane bioreactor (MBR) plant to treat wastewater from SPU sewers and supply reclaimed water to irrigate the Catholic Cemetery.	0.04 mgd	$4.2	$74
Jackson Park Golf Course[1]	Construction of transmission pipeline from the Brightwater reclaimed water backbone pipeline at the Ballinger Way Portal to supply reclaimed water to the Jackson Park Golf Course.	0.1 mgd	$7.2	$180
Urban commercial core/Myrtle Edwards Park	Construction of an MBR plant at Myrtle Edwards Park to treat wastewater from SPU sewers and construction of a distribution system grid in the downtown area to supply reclaimed water to new developments.	0.4 mgd	$38.2	$175
West Seattle Golf Course (A)	Construction of an MBR plant to treat wastewater from SPU sewers and supply reclaimed water to irrigate golf course.	0.05 mgd	$3.0	$70
West Seattle Golf Course (B)	Construction of an MBR plant to treat wastewater from King County sewers and supply reclaimed water to irrigate golf course.	0.06 mgd	$5.5	$107

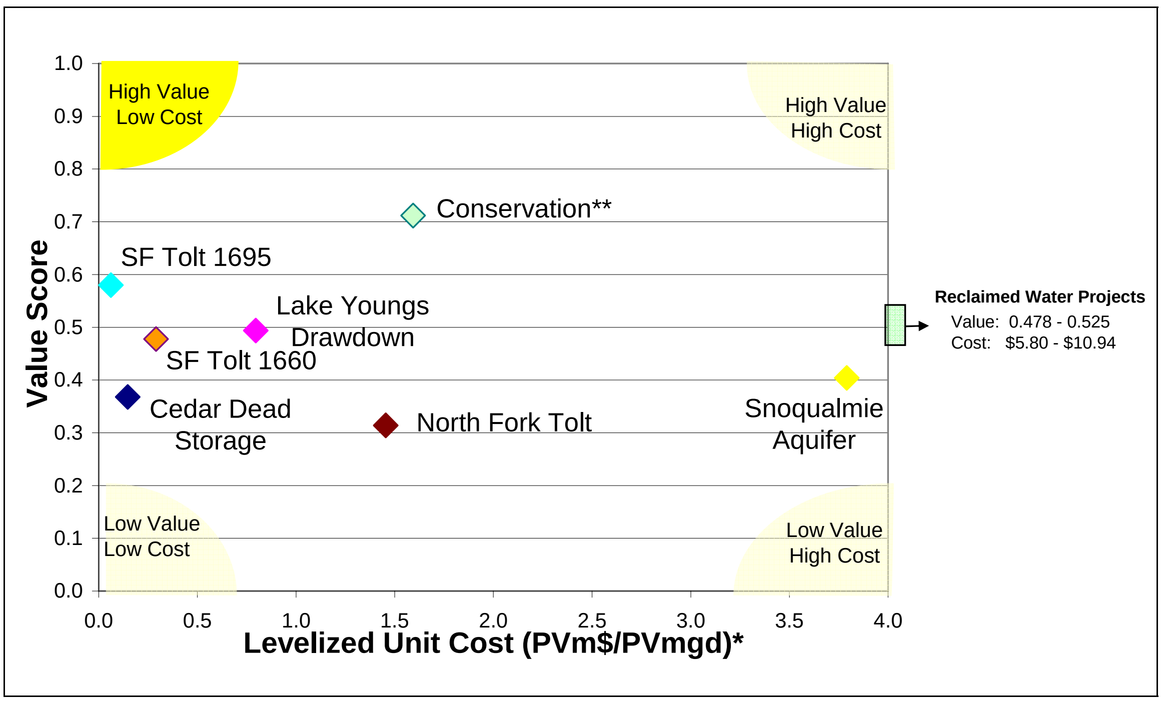
[1] Assumes Jackson Park Golf Course is using SPU water instead of its own wells.

Evaluation of Conservation as a Supply Source. The Water Supply Planning Model was also used to analyze water conservation as a possible source of future supply. Using data from SPU's CPA updated in 2004 and 2006, 10-year programs of varying levels of savings and costs were evaluated. Results are presented for a 10-year program achieving 4 mgd of cumulative savings at an annual cost of $6 million. Although this information is based on conservation measures identified in the 2006 CPA, it is likely that improvements in technology will decrease program costs or introduce new measures that would produce more savings at lower costs. As this information becomes known, it can be incorporated in the model and included in the evaluation of source options.

Evaluation of Desalination of Seawater as a Supply Source. In addition to evaluating traditional new supply sources, investigating reclaimed water sources, and analyzing conservation, SPU recently studied advances in desalination technology and their associated costs. Desalination technology has improved, and unit costs for desalinated seawater are becoming more competitive with other supply options around the country. The construction of a 25-mgd desalination plant in Tampa Bay, Florida, has raised awareness that the life-cycle costs of producing desalinated water could be as low as $2.00 per hundred cubic feet. However, desalination costs depend greatly on the specific location of the desalination facility, and a full evaluation of a desalination project would entail selection of a specific treatment source and site.

Water supply alternatives with relatively high value and low costs are preferred over other options.

Water Supply Planning Model Results. The relative values of each supply alternative were scored against each other to determine which alternatives had the highest value compared to their costs. The scores assigned to each category for all alternatives are based on current assessments made by SPU staff. In this framework, alternatives with relatively lower costs and higher value are preferred over others. Figure 2-6 graphically displays the findings for all alternatives except desalination, which was not developed to a sufficient level of detail to accurately estimate costs and benefits.



* Calculated assuming all sources on line in 2050.
** 4 mgd conservation program may begin in 2045 and phase in over a 10-year period.

Figure 2-6. Value Score vs. Levelized Unit Cost for Supply Alternatives

The results of the evaluation for each of the future water supply alternatives are summarized briefly below:

- Traditional Supplies. The model results indicate that the lowest cost and highest value alternative is limited drawdown of South Fork Tolt Reservoir from 1,710 feet to 1,695 feet. The higher cost and lower value alternatives include the North Fork Tolt diversion and Snoqualmie Aquifer. Cedar Dead Storage, South Fork Tolt additional drawdown to 1,660 feet, and Lake Youngs drawdown are all within a range of acceptable values and costs.

- Reclaimed Water Projects. The reclaimed water analysis shows that reclaimed water projects, while having a higher value score than the Cedar Dead Storage, North Fork Tolt Diversion and Snoqualmie Aquifer projects, are much more costly than the South Fork Tolt Reservoir limited drawdown, conservation, and the other traditional supply alternatives analyzed. Because lower cost reclaimed water projects may present themselves in the future, SPU will continue to watch for situations where reclaimed water projects may be preferred over other available options. The value scores and costs would be updated to reflect the specific characteristics of reclaimed water projects identified at the time such supply investment decisions are considered.

- Conservation. Conservation provides the highest value of all alternatives examined, and should be included in the evaluation of future supplies along with Cedar Dead Storage, South Fork Tolt additional drawdown to 1,660 feet, and Lake Youngs drawdown. As mentioned previously, lower cost conservation technologies may be developed prior to the time when a new supply source is needed; future supply analyses should use up-to-date information on conservation measures.

- Desalination of Seawater as a Supply Source. Using the 25-mgd desalination plant in Tampa Bay, Florida, as an example, desalination could have levelized unit costs that are roughly the same as South Fork Tolt additional drawdown to 1,660 feet and Lake Youngs drawdown, with a value score slightly below these alternatives. However, desalination costs are extremely site sensitive, and the Tampa Bay result should be considered as only a rough estimate. As additional water supplies are needed in the future, SPU may consider conducting a desalination feasibility and siting study to lay out conceptual plans for a desalination facility at a particular site so that a more complete evaluation of costs and environmental concerns can be developed. Meanwhile, SPU plans to stay abreast of the technological and cost-savings advances in desalination and new desalination projects around the nation.

Sensitivity Analysis. The potential effects from climate change uncertainties on the supply investment decisions can be tested by varying the firm yield from existing sources without needing to assign probability distributions. The sensitivity analysis produces a "rainbow diagram" that shows the affect of potential climate change on when and which sources might be required in the future, as well as their potential cost. This diagram shows the expected value of costs for different reductions in firm yield resulting from climate change. This method can be used in the future when specific supply options are being considered for development.

Despite the potential for declines in supply due to future climate change, there is no need for additional source development at this time.

Supply Investment Strategy. As described earlier, the Demand Forecast Model indicates that due to SPU's estimated ability to meet demand with a high (70 percent) certainty until 2060, there is no need for additional source development at this time. Even if 20 years are needed to develop a source, significant investments in new supply planning need not occur for several decades. Therefore, SPU's supply investment strategy is as follows:

- Plan for meeting future demand based on the official forecast, which represents the best estimate of known factors that influence demand and includes those demands that SPU will need to meet in the future.

- Update analysis as significant changes are made to demand forecasts or yield estimates or when more information is obtained for key uncertainties.

- Revisit forecasts at least every six years during water system plan updates.

- Collaborate with regional planning partners.

- Keep the current menu of supply options open and review if/when significant decisions need to be made about investing additional funds into such supply options.

- Evaluate South Fork Tolt Reservoir levels of drawdown below elevation 1,710 feet that could be used for potential additional future supply by continuing to manage operations at the Reservoir to limit temperature impacts downstream of the dam, and collect data on temperature and turbidity at low reservoir conditions.

2.4.2 Consistency with Other Planning

In planning to meet future demand, it is necessary to coordinate with other planning efforts to ensure consistency. Such plans include the King County coordinated water system plans, the water system plans of SPU's wholesale customers, the *King County COMPLAN*, Seattle's *Comprehensive Plan*, water system plans of adjacent water purveyors, King County's *Regional Wastewater Services Plan*, and watershed plans. Each of these plans and their relevance to SPU's water resources and water system planning is described below.

Coordinated Water System Plans

Three of the four coordinated water system plans (CWSPs) in King County are for areas served by the SPU regional water system, including east King County, south King County, and Skyway/Bryn Mawr. (The fourth CWSP is for Vashon.) SPU worked with the regional water associations responsible for developing those plans to ensure coordination with SPU planning. SPU participates in the development and updates of these plans to varying degrees, depending on the extent to which SPU's service area overlaps with the CWSP area. SPU staff also maintains regular contact with regional water associations on issues related to SPU's *Water System Plan*.

There has been some discussion of CWSPs being updated to reflect current work by Cascade to pursue Lake Tapps as a new source of supply. Alternatively, King County may initiate a new CWSP with Cascade. Should the existing CWSPs be updated, SPU would coordinate with regional water associations as it has in the past in the development of such updates. If King County and Cascade initiate a new CWSP, SPU would work with Cascade to ensure consistency between the Seattle regional plan and any new plan that might be developed.

Wholesale Customers' Individual Water System Plans

As SPU's wholesale customers update their water system plans for their own water supply and distribution systems, SPU staff coordinates with them so that their water system plans maintain consistency with SPU's *Water System Plan*. For most customers, this includes SPU review of their draft plans in the following key areas:

- Assumptions about the quantities and pressures available from SPU transmission lines.
- Demand forecasts to ensure consistency of population forecasts among Seattle and its wholesale customers.
- Responsibilities that the customer shares with SPU, such as distribution system water quality monitoring.
- Conservation programs.

SPU does not comment on water system plan demand forecast and conservation elements for wholesale customers now purchasing water through the Cascade because SPU is not involved with Cascade planning in these areas.

SPU participates in and coordinates with other regional planning efforts to ensure consistency.

Since the *2001 Water System Plan*, SPU has provided input and comments on water system plans from Bothell, Coal Creek, Cascade, Kirkland, Redmond, Skyway, Soos Creek, Tukwila, and Water District 20. SPU will continue working closely with wholesale customers to coordinate regional water supply planning activities.

King County COMPLAN

Most of SPU's service area is within incorporated areas of King County. A very small part of its retail service area is in unincorporated King County. SPU's *2007 Water System Plan* aims to be consistent with the *King County Comprehensive Plan* (*COMPLAN*) to be sure that growth targets within the SPU service area match the availability of water supply to serve related demand. In addition, SPU's *2007 Water System Plan* is consistent with the policies in the COMPLAN, including those for Water Supply and Floodplain Management.

The 2004 update of the County *COMPLAN* describes the urban growth boundary as being the one adopted by the County Council in 1994. This has been factored into the demand forecast.

City of Seattle's Comprehensive Plan

Seattle's *Comprehensive Plan* relates to this water system plan in regard to water distribution issues. Planned population increases and changes in land uses are important to how SPU conveys water throughout the distribution system.

Although minor changes have occurred more often, the last major update to the *Comprehensive Plan* was in 2004, as a result of the

10-year review required by the Growth Management Act. The major change affecting the water distribution system was the designation of South Lake Union as Seattle's sixth urban center. The other five urban centers are Downtown, First Hill/Capital Hill, Northgate, University Community, and Uptown Queen Anne. The Utilities Appendix of that plan concludes that improvements to the existing distribution system will be needed to support growth over the 20-year life of the *Comprehensive Plan*, in the urban centers and elsewhere. It assumes that most of these improvements will be paid for by developers and not through rates.

Adjacent Purveyors

A number of water purveyors within SPU's water service area and adjacent to existing SPU wholesale customers are not themselves current SPU customers. These include Water District No. 54, Lakehaven Utility District, City of Kent, City of Auburn, Water District No. 111, Mirrormont, Northeast Sammamish Water District, Union Hill, Ames Lake, Carnation, Fall City, and several other smaller purveyors. When water system plans for these systems are received, SPU reviews them for compatibility and consistency in areas such as assumptions about water demand forecasts, transmission needs, and water quality issues. None have been received since 2001.

Purveyors Beyond the Boundaries of SPU's Service Area

As a regional water supplier, SPU is an active participant in the update of the *2001 Central Puget Sound Water Supply Outlook*, produced by the Central Puget Sound Water Suppliers' Forum for the three-county region of Snohomish, King, and Pierce Counties. Being involved in this process helps ensure coordinated water supply planning throughout the region and between the three major utilities in central Puget Sound: Everett, Tacoma, and Seattle. It also highlights opportunities for efficiencies that can help to reduce impacts from utilities.

In addition, SPU is engaged in a regional planning effort initiated by King County as a way to produce good technical information that will assist in the planning activities of the utility. The linkage between these two planning efforts helps in understanding water resource issues related to providing water for both people and fish, and supports planning processes throughout the region.

Regional Wastewater Services Plan

In 2004, King County published an update to its *Regional Wastewater Services Plan* (*RWSP*). The *RWSP* contains proposals for disposal of the region's wastewater, including using reclaimed water as a new source of water supply. Several possible uses for reclaimed water to offset demand for potable water are identified in the *RWSP*. SPU participated in the development of the *RWSP* and continues to work with the County in assessing the potential for reclaimed water, developing pilot projects, and other efforts as part of the King County reuse task force.

Watershed Plans

The only watershed plans in the SPU retail service area are Chinook Salmon Conservation Plans for the Cedar River/Lake Washington/Lake Sammamish Watershed (WRIA 8) and the Green/Duwamish and Central Puget Sound Watershed (WRIA 9), which were finalized in 2005. This watershed planning was within the framework of RCW 77.85, Salmon Recovery. This is not one of the types of watersheds plans for which a water system plan must show consistency according to the Municipal Water Law.

The 50-year Cedar River Watershed HCP that SPU developed was agreed to with federal and state resource agencies in 2000 and is now being implemented. SPU continues to be in compliance with the HCP.

Salmon Recovery Plans

Seattle participates in salmon recovery processes conducted under the framework of RCW 77.85 in the watersheds associated with its water supply and service area: WRIAs 7 (Snohomish River Basin), 8, and 9. The WRIA 7, 8, and 9 plans recognize that salmon recovery is a long-term effort and include a scientific framework, lists of priority actions, comprehensive action lists, adaptive management approaches, and funding strategies. The City of Seattle has implemented habitat restoration and protection projects, and addressed salmon habitat through its land use and public outreach policies and programs.

As part of WRIA 7, 8, and 9 salmon recovery efforts, Seattle has implemented a number of early actions. Examples of these efforts include:

- Lower Cedar River habitat restoration projects.
- A number of shoreline and wetland restoration projects on Lake Washington.
- Improvements at the Ballard Locks in conjunction with the Corps of Engineers for outward migration of salmon.
- Purchase of the Salmon Bay Natural Area downstream of the Locks for habitat benefits.
- Participation in many research efforts with the goal of ensuring effectiveness of restoration projects in Lake Washington and on the Duwamish River.
- Acquisition of habitat lands on the Tolt River by Seattle City Light.
- Staff leadership and major funding for feasibility and design of the Tolt River levee setback project.
- Funding over several years to Tulalip Tribes for juvenile salmon research on the Snoqualmie River.

The Cedar River Watershed HCP covers most of the costs for the projects recommended in the WRIA 8 plan for the Upper Cedar River and the Lower Cedar River. It will also provide funding for improving fish passage and water conservation at the Locks as alternatives for improving conditions at the Locks are identified.

2.4.3 Infrastructure Needs and Improvements

SPU maintains its water resources facilities for safe and reliable operation to ensure water supply is available for its customers. Three infrastructure projects, Chester Morse Lake dead storage facilities, Cedar moraine safety improvements, and Landsburg flood passage improvements, comprise the major capital improvement focus for SPU's Water Resources business area. These projects are described below.

Chester Morse Lake Dead Storage Facilities

The Chester Morse Lake pumping plants are currently used to access dead storage when water levels in the lake are low, such as during droughts. Pumping provides additional flow to the Masonry Pool and the Cedar River to meet customer needs and instream flow requirements during drought or other supply emergencies.

Stop logs are long wooden structures that are used like a dam to contain water in a pond or pool.

In recent years, maintenance work and capital improvements have been completed to ensure operability and restore flow capacity of the pumping plants and associated facilities. This work included deepening the outlet channel, modifying the discharge dike to increase its height and allow use of stop logs, improving the discharge pipes, testing and replacing electrical cable, and making electrical safety improvements. Even with these improvements, concerns remain over the reliability and readiness of these facilities. Of particular concern is the long-term stability of the outlet channel and its flow capacity. Infilling of the outlet channel has resulted in the need to begin pumping operations sooner to supplement gravity flow to the Masonry Pool. Also of concern is the long lead time needed to mobilize the pumping plants prior to actual use. Up to two months are needed to ready the plants, which can lead to costly efforts that later prove to be unnecessary when plants are then not subsequently needed or put to use.

SPU is working on preliminary engineering studies to evaluate options and recommend the most cost-effective and reliable system for delivering water from dead storage during droughts and other emergencies. Options under analysis include modifications to the existing system, construction of a new pump station and discharge pipelines, and tunnel options. Various options for stabilizing the outlet channel are also being evaluated. One promising option is to replace the system with a land-based pump station and new pipeline that would discharge water at the downstream end of the outlet channel.

Cedar Moraine Safety Improvements

Cedar moraine safety studies were initiated by SPU as required by the Department of Ecology Dam Safety Section in response to recommendations in a March 2000 consultant safety inspection of the Masonry Dam and associated Masonry Pool and moraine. The objectives of the study were to determine the stability of the moraine slopes under both static and seismic conditions and to improve the monitoring of the moraine. The geotechnical investigations and stability analyses of the moraine slopes were completed in 2006. The results of the studies showed that one slope in the area of West Boxley Creek appeared to have the potential of a groundwater burst flood event that could cause unacceptable damage during a large earthquake. This result was based on a conservative assumption, which SPU may choose to verify by field investigation before committing to an improvement. Assuming that a remedial measure is required, the most likely improvement would be to install three horizontal drainage tunnels extending about 100 feet into the face of the slope. Water from the drains would be guided towards natural channels in the area and would not change the flow regime. Improvements would also be made to the monitoring of the moraine as recommended by the consultant. Whatever approach is taken, it will be implemented so as to satisfy state dam safety criteria.

Landsburg Flood Passage Improvements

Since the Cedar River flooded in Fall 1990, there have been concerns about flood debris, such as large, fallen trees uprooted during high flows, blocking the spillway gates at Landsburg Diversion Dam during major floods. SPU has completed preliminary engineering and life-cycle cost analyses to improve the flood passage capabilities at the dam. The selected alternative consists of replacing two existing spillway gates with one larger, radial gate and installation of a trash rake system for debris handling. After completion of these improvements, SPU crews will be better able to remove logs and other flood debris from the face of Landsburg Dam. This will reduce the risk of overtopping of the dam during large flood events, which could potentially cause severe erosion of the embankments and place the dam at risk of failure.

2.4.4 South Fork Tolt Reservoir Studies

SPU has traditionally operated the South Fork Tolt Reservoir to serve its customers based on historical operator experience and perceived knowledge of the reservoir’s operational constraints. In an effort to better understand the actual constraints of the system and the potential costs, benefits, and risks for pushing those boundaries, SPU is studying the operations of the South Fork Tolt Reservoir.

There is potentially significant benefit to expanding the historical operating range of the reservoir. To do that, SPU needs to conduct studies and analyses to increase the understanding of the constraints and environmental issues associated with reservoir operations. Topics to be potentially included in this comprehensive analysis of South Fork Tolt Reservoir operations are drawdown below elevation 1,710 feet; raising the spillway ring gate to allow higher summer storage volumes; dynamic rule curve application for flood season operations; reservoir temperature and turbidity management; water quality evaluation of releases to river and treatment plant; drawdown/refill strategies; flood management; and instream flow. During the course of these studies SPU will work with interested stakeholders, including the Tolt Fisheries

Advisory Committee, which includes the Tulalip Tribes, and state and federal agencies.

2.4.5 Supply Management Service Level

In addition to needed infrastructure and operational studies, SPU lacks a supply management service level that specifies an upper limit for how often customers should expect curtailments. It is a common misconception that with demand below firm yield, SPU should only rarely need to ask customers to curtail water use. This would be true if water managers knew in advance how dry each year was going to be. However, precipitation is inherently difficult to forecast, and thus, stream flows and reservoir inflows are difficult to forecast. Water managers do not know how much precipitation will occur during a year, nor do they know when the fall rains will return. In years that begin badly, with low snow pack and/or very dry or warm spring weather for example, responsible water supply management dictates early action so that possibly needed savings can be accomplished during the high water use seasons of spring and summer. Such actions may end up being overly conservative if the rains return normally in the fall. This inability to accurately predict the coming season's precipitation patterns or totals produces the apparent paradox of having occasional water shortage advisories or curtailments at the same time that considerable long-term excess supply exists.

This paradox is a result of how water managers must operate their systems year-to-year. When water managers make decisions in the spring, they do so without the knowledge of what the summer or fall will bring in terms of temperatures and particularly rainfall. Those decisions, therefore, reflect the level of risk SPU is willing to take that reservoirs will not go below normal minimum levels in the fall. This risk exists regardless of demand levels and firm yield. As a result, there may be more curtailment events than would be needed if the ability to reliably predict future water conditions existed.

To provide a measure of frequency of water advisory or curtailments that customers may expect, SPU will define and develop a supply management service level. This service level will also characterize how well the supply system is managed in any given year. Historic curtailment frequencies, current demand levels, and operational capabilities will be some of the key elements considered in the service level development process. While developing this service level, SPU will consider how new or improved management strategies, including enhanced modeling and forecasts and deployment of alternative supplies and emergency reserves, may be used to help limit the frequency of customer curtailments.

2.5 Implementation/Action Plan

In the absence of a need to develop new water supplies at this time, SPU's implementation/action plans in the Water Resources business area focus on continuing conservation efforts, updating the water supply analysis, studying the impacts of additional drawdown of the South Tolt Reservoir, improving infrastructure reliability, exploring operational flexibility to optimize existing supply, developing a supply management service level, and continuing to coordinate with other regional providers and planners. A summary of the implementation/action plan for the Water Resources business area is as follows:

- Continue to implement water conservation efforts including the Regional 1% Program and the City of Seattle I-63 SO, and prepare to implement measures to meet the 2011-2030 Regional Conservation Program goals.

- Plan to meet future demand based on the official forecast, which represents the best estimate of factors that influence demand and includes those demands that SPU needs to provide for in the future; update the analysis as significant changes are made to demand forecasts or yield estimates, or when more information is available regarding key uncertainties, such as the potential impacts of future climate change and climate variability, and supply alternatives, such as reclaimed water and desalination; revisit the analysis at least every six years during water system plan updates.

- Learn more about what level of additional drawdown the South Fork Tolt Reservoir can accommodate to support additional future supply; understand the potential impacts of increased drawdown on turbidity and temperature downstream of the dam by collecting temperature and turbidity data.

- Complete infrastructure improvements:
  - Evaluate options and recommend the most cost-effective and reliable system for delivering water from Chester Morse Lake dead storage during drought conditions and other emergencies.
  - Complete remedial work and monitoring improvements to address Cedar moraine safety issues, as appropriate.
  - Implement the Landsburg Dam flood passage improvements.
- Develop adaptation strategies that boost the system's operational flexibility and optimize existing water supply to enhance response to a wide range of varying supply/demand conditions (year-to-year hydrologic variability, potential future impacts of climate change and climate variability, etc.).
- Define and develop a supply management service level; consider how management strategies, including improved modeling and forecasts and deployment of alternative supplies and emergency reserves, may be used to help limit the frequency of customer curtailments.
- Continue to coordinate with regional water planning partners.

Chapter 3
Water Quality and Treatment

Water quality analyst at SPU's laboratory

SPU's water system includes two state-of-the-art water treatment facilities for the Cedar and South Fork Tolt source waters, treatment and intake screening facilities at Landsburg, intake screening facilities at the Tolt Regulating Basin, and in-town disinfection facilities at reservoirs and well sites. Each of these facilities is operated and maintained to ensure that the potable water SPU delivers to its customers meets high public health and aesthetic (e.g., appearance, taste, and odor) standards.

SPU's water system includes two state-of-the-art water treatment facilities for the Cedar and Tolt source waters. The treatment facilities provide multiple barrier treatment processes to offer high levels of treatment prior to transmission and distribution.

This chapter of the *2007 Water System Plan* focuses on the Water Quality and Treatment Business Area, which administers SPU's drinking water quality and treatment programs, projects, services, and capital assets. Key functions of this business area include managing SPU's drinking water regulatory compliance, oversight of the Tolt and Cedar Treatment Facilities and their contract operations, managing distribution system water quality, and overseeing water quality and treatment related capital improvement projects. The Water Quality and Treatment business area is unlike other business areas in that its programs affect infrastructure and practices in the Transmission and Distribution, Water Resources, and Major Watersheds business areas. This chapter also includes descriptions of the drinking water regulatory requirements SPU must meet or exceed, as well as SPU's history of compliance.

3.1 Water Quality and Treatment Policies

SPU has developed policies that focus on maintaining drinking water quality from SPU's raw water sources through the treatment, transmission, and distribution systems and all the way to customers' water taps. The following sections describe these policies in greater detail, discuss changes in the policies from the *2001 Water System Plan*, and summarize the key issues and concerns evaluated during development of the policies.

3.1.1 High-Quality Drinking Water Provision Policy

SPU's primary sources, the Cedar and South Fork Tolt Rivers, have exceptional water quality and source water protection, as well as state-of-the-art treatment facilities. Source water protection and treatment together ensure that the quality of Seattle's drinking water is excellent when delivered to the SPU transmission system. Water from the City's wells also has high quality and natural protection due to the depth of the wells. As water leaves these sources and travels to customer service connections, SPU continues to protect the quality of water through careful attention to the planning, design, operation, and maintenance of the transmission and distribution systems. Covering storage reservoirs helps to protect water quality as the water travels through the transmission and distribution system. After drinking water passes through the customer's meter, there remains an opportunity for water quality to be impaired from customer cross connections and from contaminants, particularly lead, leaching from customer plumbing systems.

SPU revised its water quality policy from the *2001 Water System Plan* to provide new direction on how SPU should approach meeting and/or exceeding drinking water quality objectives. The policy from the *2001 Water System Plan* was updated to reflect the following three major shifts:

- Incorporating the concept of "triple bottom line" (i.e., financial, social, and environmental) cost/benefit analysis.

- Placing an even greater emphasis on managing drinking water quality to protect public health and maintain or improve public confidence, in addition to complying with drinking water quality regulations.

- Recognizing the impracticality of maintaining the same quality of water throughout the system.

Policy Statement

Manage drinking water quality from the water source to the customers tap in coordination with wholesale customers to protect public health, comply with drinking water quality regulations, and maintain and improve public confidence in the drinking water quality.

1. *Factor protection of water quality into the planning, design, operation, and maintenance of all system components, including the transmission and distribution systems.*

2. *Pursue initiatives that further public health or customer confidence objectives when these initiatives are justified by a triple-bottom-line analysis, even if regulatory compliance objectives are otherwise being met.*

3. *Continue the multiple-barrier approach to protecting water quality that includes source protection and treatment.*
4. *Continue to provide support for maintaining water quality in customer plumbing as deemed appropriate.*
5. *Provide wholesale and retail customers with clear, accurate, and timely information on water quality issues so that public confidence is maintained.*
6. *Support research on emerging drinking water issues and participate in the development of new state and federal legislation and regulations on drinking water quality, both directly and through water utility associations.*

3.1.2 Watershed Protection Policy

By owning most of the land in the Cedar Watershed and 70% of the Tolt Watershed, SPU maximizes source water protection.

For over a hundred years, the City's principal strategy for protecting water quality in its watersheds has been to acquire ownership of watershed lands to control human activities and maximize protection of source water quality. As a result, the City has acquired virtually complete ownership of Cedar River Watershed and approximately 70 percent ownership of the South Fork Tolt watershed (the remaining 30 percent is publicly owned by the US Forest Service). The Watershed Protection Policy provides guidance as to how SPU will manage facilities and activities affecting water quality in the watersheds.

The development of the Watershed Protection Policy followed the emergence of water supply security as an important societal concern. The primary emphasis of this policy is on controlling access to and activities within the watershed. While not previously stated in a single policy, the elements of the policy have been in practice for the past 100 years. Therefore, the policy does not represent a significant shift from past SPU policies and practices as detailed in the *2001 Water System Plan*. This policy will have a small public and social impact as a result of continuation of the restrictions on access to protected watershed areas. The restriction is necessary, however, to protect against greater regulatory, asset, and service reliability, security, financial, and public health impacts.

Policy Statement

Control human activity and be prepared to respond to emergencies in the municipal watersheds to maximize protection of drinking water source water quality.

1. *Require that all individuals and groups have approval from the Director of SPU or designee for access to the municipal watersheds.*[1]
2. *Enforce trespass and other laws and regulations related to municipal watershed access and deterrence of unauthorized use, taking additional security measures when needed along known security trespass corridors or where SPU property is adjacent to residential areas.*
3. *Meet all current federal regulations for unfiltered surface water supply in the Cedar River watershed, including provisions of the Cedar supply's Limited Alternative to Filtration, and filtered surface water supplies in the South Fork Tolt watershed that require the identification of municipal watershed boundaries. Signs, fencing, and gates will be used to meet these regulations and to deter unauthorized use and trespass.*
4. *Prohibit public access for fishing in SPU's municipal watersheds*
5. *Prohibit public access for hunting in SPU's municipal watersheds, unless it is deemed necessary by the Director of SPU for the protection of water quality, allowing tribal hunting in accordance with treaty rights or by specific agreements.*
6. *Pursue land ownership, landowner agreements, and/or legislation to protect SPU municipal watersheds, emphasizing land ownership, when feasible, to provide the greatest level of control and watershed protection.*
7. *Aggressively pursue prevention and suppression of all wildfires on municipal watershed lands.*
   a. *Include public education, communication of industrial fire precaution levels, forest patrols, weather monitoring, and fuels management in wild fire prevention program.*
   b. *Prioritize human life and safety (both for the public and for those fighting the wildfires) as highest priority.*
   c. *Then emphasize containment of a wildfire to the smallest acreage possible.*
   d. *Use water from any water body within the Cedar and Tolt watersheds for fire suppression on a case-by-case basis as decided by the Director of SPU or designee.*

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[1] See policy regarding watershed recreational trails in SPU's Watershed Recreation Policy.

e. *Use fire retardant materials when authorized by the Director of SPU or designee.*

3.2 SERVICE LEVELS

SPU's service level in the water quality and treatment business area focuses on meeting federal and state regulatory requirements. This is captured in a single service level objective and target for drinking water quality as shown in Table 3-1.

Table 3-1. SPU's Service Level for Managing Water Quality and Treatment Assets

Service Level Objective	Service Level Target
Promote a high level of public health protection and customer satisfaction with drinking water quality.	Meet all health-related and aesthetic regulations administered by the Washington State DOH Drinking Water Program for the Seattle regional water system.

SPU's service level target is to meet health-related regulations (i.e., primary maximum contaminant levels and treatment requirements), aesthetic regulations (i.e., secondary maximum contaminant levels), and other aesthetic criteria (e.g., appearance, taste, and odor). SPU has been successful in meeting this service level. In 2005, SPU met all drinking water regulatory requirements. Taste and odor complaints have decreased since SPU began operations at the Cedar Treatment Facility. SPU's approach to continuing to achieve its service level objective is described in the following section.

3.3 EXISTING FACILITIES AND PRACTICES

To achieve its water quality and treatment service level, SPU has expended a great deal of effort over the past decade and continues to make concerted efforts in order to ensure compliance with Washington State Department of Health (WDOH) drinking water regulations. SPU operates facilities, monitors water quality at those facilities, and engages in a number of practices designed to bring safe, high-quality drinking water to its customers. This section summarizes SPU's record of regulatory compliance, identifies SPU's treatment facilities, and summarizes its operation and maintenance practices to ensure excellent water quality and a high level of customer satisfaction.

3.3.1 Regulatory Requirements and Compliance

Federal and state statutes and administrative regulations require the utility to meet certain water quality criteria and performance standards. The following subsections identify the standards and requirements that SPU must achieve and summarize SPU's performance in meeting those standards and requirements.

Total Coliform Rule

SPU collects required monthly samples from its retail service area distribution system and tests for coliforms, which are naturally present in the environment and are used as an indicator of whether other, potentially-harmful, bacteria may be present. As system improvements, especially better disinfection systems, have been implemented over recent years, Seattle's success in meeting the total coliform rule requirements have improved greatly.

SPU has been well within regulatory requirements for coliform since the startup of the Cedar Treatment Facility in 2004.

SPU experienced an increase in positive coliform samples from 2002 to 2004. This was due, in part, to more sensitive laboratory methods for detecting the bacteria. It was also a result of the proliferation of a particular coliform species in Lake Youngs that fed on a large algal bloom in the lake. As indicated by Figure 3-1, SPU has been continuously in compliance with the Total Coliform Rule. Since the startup of the Cedar Treatment Facility in 2004, SPU has been well within the regulatory requirement of less than 5 percent of samples with detectable coliform and no *E. coli*.

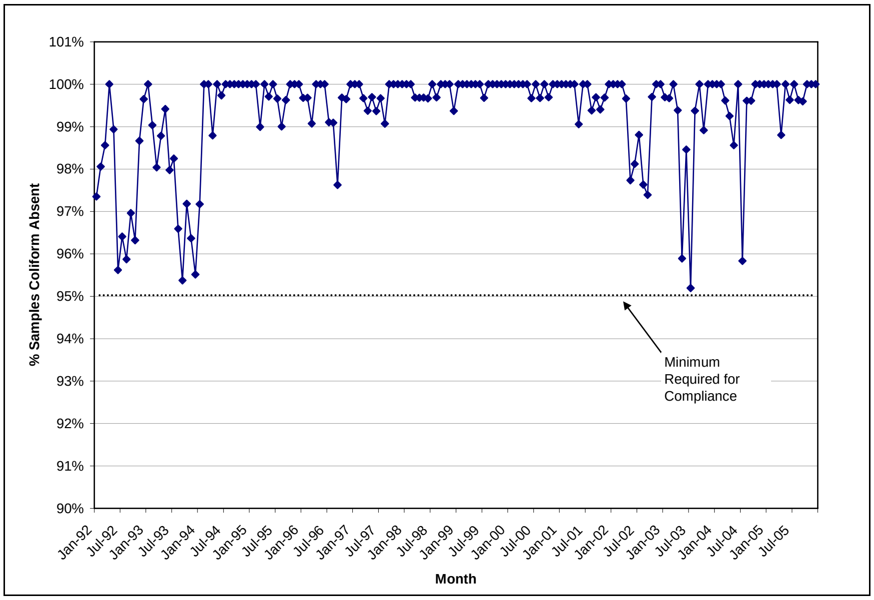

Figure 3-1. Monthly Coliform Data from SPU Water Distribution System

Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) contains disinfection and filtration requirements for all public water systems that use surface water or a groundwater source that is under the direct influence of surface water. Several revisions to the original rule have been made since 1989. The latest revision to the SWTR, the Long Term 2 Surface Water Treatment Rule (LT2SWTR), focuses on controlling *Giardia* and *Cryptosporidium* in surface water supplies. Now, both the Cedar and Tolt supplies must be monitored for *Cryptosporidium* for two years. To date, the monitoring results indicate that no additional treatment is required at either the Cedar or Tolt Treatment Facilities to control *Cryptosporidium*.

Tolt Supply. With completion of the Tolt Treatment Facility in 2001, the supply from South Fork Tolt River must meet all the requirements of a surface supply using filtration and disinfection. The Tolt Treatment Facility operations contract includes water quality performance requirements that meet and, in most cases, exceed the regulatory filtration and disinfection requirements. The Tolt Treatment Facility has had no treatment violations since startup.

Cedar Supply. Construction of the Cedar River Treatment Facility was completed in 2004. The Cedar River water supply system was designated as having “limited alternative to filtration” (LAF) status which authorizes SPU to operate the Cedar source without filtration treatment. LAF status is granted because Cedar source water is produced from a watershed that is 100 percent in public ownership, with no residential, commercial or industrial development, and the treatment system employs a multi-stage disinfection process that provides greater protection against microbial contamination than can be provided by traditional filtration and chlorine disinfection.

Like the Tolt Treatment Facility, the Cedar Treatment Facility operations contract includes water quality performance requirements that meet and, in most cases, exceed regulatory requirements. Since it began operating in 2004, the Cedar Treatment Facility has experienced no treatment violations.

Open Reservoirs. The new requirements of the SWTR require SPU to give WDOH written notice by 2008 as to which approach will be used to meet the new requirements for open reservoirs, and submit a covering plan by 2009. Although SPU already has an open reservoir covering plan approved by WDOH, an update to that plan will be submitted. The covering plan is described in greater detail later in this chapter.

Disinfection By-Product Rule

In general, Seattle's high quality source water and upgraded treatment result in low concentrations of disinfection by-products, such as trihalomethanes and haloacetic acids, two by-products that can result from reactions between chlorine and natural organic matter. Trihalomethane and haloacetic acid monitoring results since 2002 are presented in Figure 3-2 and Figure 3-3. The results are all well below the regulatory limits. Cedar River water has historically been relatively low in disinfection by-products. Disinfection by-product levels in the South Fork Tolt River water decreased substantially with startup of the Tolt Treatment Facility and are now comparable to those of the Cedar source.

To prepare for implementation of the 2006 Stage 2 Disinfectants and Disinfection By-Products Rule that will take effect in 2012, SPU has begun a sampling program to identify sites in the distribution system where the highest disinfection by-product levels are likely to be found, and it has begun compliance testing at those sites. Based on testing conducted to date, SPU does not anticipate much difficulty meeting the by-product limits under the new rule.

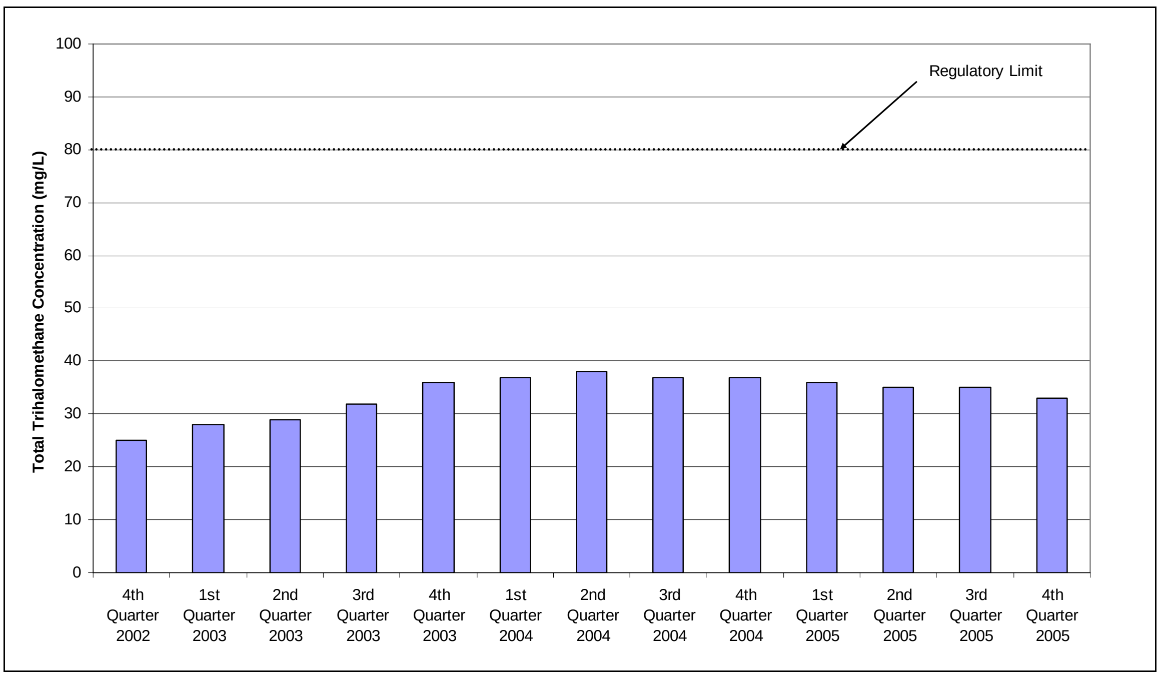

Figure 3-2. Trihalomethane Concentrations, 2002-2005

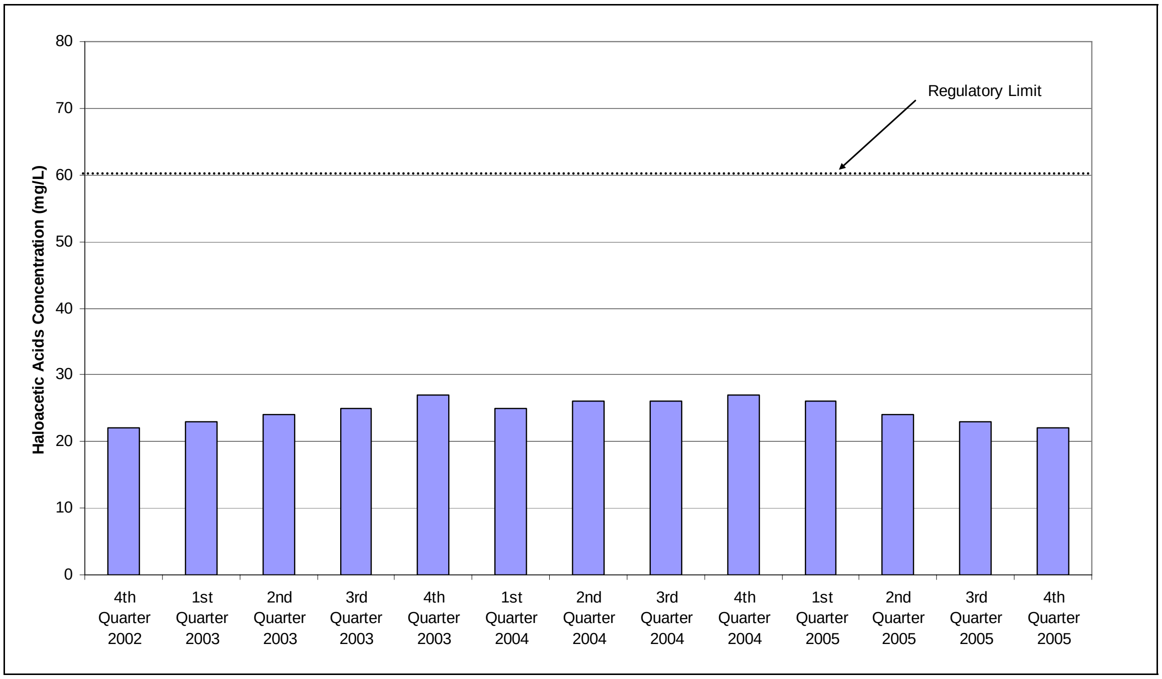

Figure 3-3. Haloacetic Acid Concentrations, 2002-2005

Lead and Copper Rule

Seattle's source and distribution water contains no significant amounts of lead or copper. Household plumbing, however, is often made of copper, and household systems can include components containing lead, such as lead-tin solder and leaded-brass fixtures, that can leach lead and copper into the water. As a result of exceeding the regulatory action level for lead in 1992 and 1997, SPU negotiated a compliance agreement with WDOH in 1997. SPU has since met the requirements of the compliance agreement through construction of the Tolt Treatment Facility, covering of two reservoirs on the Tolt system, and changes in disinfection treatment at the two reservoirs. Between 2001 and 2004, SPU conducted additional testing to optimize treatment. In 2003 and 2004, two rounds of lead and copper tap monitoring showed that SPU's water system was in compliance with the regulatory limits. In the fall of 2004, the compliance agreement was terminated.

Other Water Quality Monitoring

Source Monitoring. SPU conducts source monitoring for hundreds of potential contaminants, including inorganic chemicals, volatile organic chemicals, synthetic organic chemicals, and radionuclides. None of the Seattle water sources have had chemical concentrations near the compliance limits for any of these contaminants.

Open Storage Monitoring. SPU operates, maintains, and monitors its open reservoirs in accordance with a WDOH-approved open reservoir protection plan, discussed later in this chapter.

Closed Storage Monitoring. Throughout the year, SPU monitors the quality of water within open and covered storage facilities as part of its routine water quality monitoring program. The information guides system operations, reservoir turnover, spot disinfection, or decisions to take facilities out of service for cleaning or other actions.

Taste and Odor Sampling. Taste and odor testing is conducted at least bi-weekly by a trained flavor profile analysis panel at SPU. The testing monitors and characterizes changes in tastes and odors associated with the source waters and distribution reservoirs, especially the open reservoirs. The test data are used to ensure source treatment performance criteria are met and to inform operators about the need to take reservoirs out of service, increase reservoir turnover, overflow reservoirs, or blend sources of supply.

Miscellaneous Monitoring. SPU also conducts water quality monitoring at the Landsburg Diversion on the Cedar River, Chester Morse Lake, Lake Youngs, the Tolt Reservoir, and the Tolt Regulating Basin. Nutrients, algae, and other basic chemical and physical parameters such as pH, temperature, total organic carbon, ultraviolet absorbance, dissolved oxygen, reservoir stratification, and visibility throughout the water column are monitored.

3.3.2 Source Water Protection Programs

SPU's finished water quality is excellent, in part, because of SPU's substantial efforts to protect its water sources. Those source protection efforts are described below.

Watershed Protection

SPU's substantial efforts to protect its water sources help to ensure that the finished water delivered to customers is of excellent quality.

The primary tool for maintaining source water quality is Seattle's extensive watershed ownership, which allows SPU to restrict human access and activities within the watersheds. SPU has adopted watershed protection programs for the Cedar River and South Fork Tolt River Municipal Watersheds as well as for the Lake Youngs Reservation to ensure that SPU's source water remains of high quality and free from contamination. The programs are described in SPU's *Watershed Protection Plan,* which details SPU's activities to control activities that have the potential to adversely affect water quality in both of its surface water supplies. The Plan was submitted to and approved by DOH in 2004. The only significant change from the *2001 Water System Plan* was the addition of the Lake Youngs Protection Program.

Lake Youngs Protection Program. With the 2004 completion of the Cedar Treatment Facility, Lake Youngs Reservation effectively became a part of the Cedar River hydrographic watershed. SPU's *Watershed Protection Plan* presents a comprehensive discussion of Lake Youngs to reflect this significant change in the configuration of the Cedar supply. It describes the Lake Youngs Reservation physical characteristics; land ownership; and water quality protection measures, such as security and sanitation.

Wellhead Protection

While the two municipal watersheds supply nearly all of Seattle's raw drinking water, Seattle supplements its drinking water supplies with groundwater from the Riverton and Boulevard Park well fields, located in SeaTac, Washington. As part of the *2001 Water System Plan*, SPU prepared and WDOH approved a wellhead protection program, including inventory of potential contaminants, for both well fields. The program has not changed since 2001, other than the potential contaminant inventory being updated in 2003 and 2005.

3.3.3 Source Water Quality Summary

Water quality characteristics of the raw water from each of SPU's sources, including its three wells, are shown in Table 3-2.

Contaminants of concern that have been identified in the wells include radon in all of the wells and Dacthal mono- and di-acid degradates in the Riverton Wells. In most years the wells have not been used, but when they were, all customers were notified of the presence of these contaminants in the annual Consumer Confidence Report. These contaminants are currently not regulated by the EPA.

Table 3-2. Water Quality Characteristics of SPU's Source Water, 2000-2005

Surface Water Sources	Cedar River		Lake Youngs		Tolt River	
Parameter and Unit	Average	Typical Range	Average	Typical Range	Average	Typical Range
Turbidity, NTU	0.5	0.2 – 0.8	0.4	0.3 – 0.5	0.9	0.2 – 2.0
Temperature, °C	9	6 - 12	13	7 - 19	9	4 - 15
pH	7.6	7.3 – 7.8	7.6	7.3 – 7.8	6.9	6.6 – 7.3
Alkalinity, mg/L as $CaCO_3$	22	15 - 30	18	14 - 20	5.7	5.3 – 6.5
Conductivity, umhos/cm	56	44 - 71	56	50 - 63	22	20 - 24
UVA (@254 nm), cm-1	0.025	0.01 – 0.043	0.017	0.012 – 0.022	0.061	0.046 – 0.087
Total coliform, per 100 mL	413	48 - 921	960	7 - 2400	83	3 - 200
Fecal coliform, per 100 mL	11	0 - 23	2	0 - 5	1	0 - 2

Groundwater Sources	Boulevard Well		Riverton Wells	
Parameter and Unit	Average	Typical Range	Average	Typical Range
Temperature, °C	12	11 - 13	10	9 - 11
pH	7.0	6.8 – 7.1	7.4	7.2 – 7.8
Alkalinity, mg/L as $CaCO_3$	76	53 - 93	59	24 - 77
Hardness, mg/L as $CaCO_3$	116		83	
Conductivity, umhos/cm	270	238 - 295	195	184 - 219

3.3.4 Source Treatment Facilities

As described below, SPU operates treatment facilities at both its surface water sources and at its well field.

Cedar River Treatment Facilities

SPU operates two facilities to treat Cedar River source water, the Landsburg Treatment Facility and the Cedar Treatment Facility. At the Landsburg Treatment Facility, SPU fluoridates and chlorinates the Cedar supply. Prior to the construction of the Cedar Treatment Facility at Lake Youngs, the Landsburg Treatment Facility was the primary disinfection site for water from the Cedar River watershed. Since the addition of ultraviolet (UV) disinfection and ozonation at Lake Youngs, the chlorine addition at Landsburg serves to control invasive plant species (e.g., algae from Chester Morse Lake) in Lake Youngs and minimize microbial growth in the transmission pipeline between Landsburg and Lake Youngs.

The new Cedar Treatment Facility uses ozone, UV, and chlorine applied in series to ensure inactivation of Giardia, Cryptosporidium, and viruses.

The new Cedar Treatment Facility uses ozone, UV, and chlorine applied in series to ensure inactivation of *Giardia*, *Cryptosporidium*, and viruses. These processes also improve the taste and odor of the water from this source. The new facility has a capacity of 180 mgd.

The Cedar Treatment Facility is operated under contract by Operations Management International (OMI). The 15-year contract with OMI began in late 2004. SPU has the option to renew the contract for up to two additional, 5-year periods. At the 15- and 20-year marks, SPU will have the option to renew the existing contract, hire another operations contractor, or use SPU staff to operate the treatment facility.

South Fork Tolt River Treatment Facility

The Tolt Treatment Facility produces water comparable in quality to that of the Cedar.

A 120-mgd ozonation and direct filtration treatment facility for the South Fork Tolt River water began operation in 2001. The facility also provides fluoridation and chlorination and adjustment of pH and alkalinity for corrosion control. Treatment provided by the Tolt Treatment Facility has resulted in finished water quality comparable to that produced by the Cedar Treatment Facility.

The Tolt Treatment Facility is operated by American Water Services Camp Dresser & McKee. The 15-year operations contract began in 2001 and will expire in 2015. SPU has the same contract renewal options at the 15- and 20-year marks as it has for the Cedar Treatment Facility.

Well Field Treatment Facilities

Both well locations include sodium hypochlorite disinfection to provide chlorine residual in the distribution system, fluoridation, and sodium hydroxide addition for corrosion control. Although sodium hydroxide addition is not required, it makes the well water quality more consistent with that of treated water from the Cedar River, with which it is blended before it is delivered to SPU customers.

Condition of Source Treatment Facilities

Because of their recent construction, the Cedar River and Tolt treatment facilities are both in excellent condition. The treatment equipment at the well fields is also relatively new, and in very good condition. The Landsburg Treatment Facility is older, and SPU is in the process of analyzing alternatives to upgrade the mechanical equipment and structural components of the chlorination facilities.

Overall Finished Water Quality

The water quality characteristics of treated water as it enters SPU's transmission system are shown in Table 3-3.

Table 3-3. SPU's Finished Water Quality Characteristics

Surface Water Sources	Cedar/Lake Youngs (2005)		Tolt River (2001-2005)	
Parameter and Unit	Average	Typical Range	Average	Typical Range
Turbidity, NTU	0.5	0.2 – 0.8	0.05	0.02 – 0.1
Temperature, °C	13	4 – 25	10	4 – 15
pH	8.2[1]	8.0 – 8.4	8.2[1]	8.0 – 8.4
Alkalinity, mg/L as $CaCO_3$			19	18 – 20
Conductivity, umhos/cm	74		51	
UVA (@254 nm), cm-1	0.011	0.007 – 0.013	0.013	0.011 – 0.015
Chlorine residual, mg/L	1.4[1]	1.3 – 1.5	1.5[1]	1.4 – 1.6

Groundwater Sources	Boulevard Park Well (2000-2005)		Riverton Wells (2000-2005)	
Parameter and Unit	Average	Typical Range	Average	Typical Range
Temperature, °C	13	12 - 14	11	9 - 12
pH	8.25[1]		8.25[1]	
Alkalinity, mg/L as $CaCO_3$	104		88	
Conductivity, umhos/cm	327	285 - 362	259	206 - 348
Chlorine residual, mg/L	1.0[1]		1.0[1]	

[1] Treatment target or criterion

3.3.5 In-Town Storage Facilities

In addition to its facilities in the watersheds and at Lake Youngs, Seattle operates several water storage facilities within its service area, including open reservoirs, covered reservoirs, and standpipes and elevated tanks. SPU operates these facilities to ensure that water quality within the distribution system is protected. SPU has established a regular program of inspections for the open and closed reservoirs and reports the results of the surveys to WDOH.

Reservoir Covering/Burying

The approach for covering the open reservoirs has changed significantly since the *2001 Water System Plan*. In early 2001, SPU intended to cover most of the open reservoirs with relatively inexpensive, floating covers to retain most of the existing storage volume. Primarily because of heightened concerns about security following September 11, 2001, but also to create more open space in Seattle, SPU now plans to replace most of the open storage with new underground reservoirs and to accelerate the construction schedule. The replacement projects represent a significant amount of work. Table 3-4 summarizes the revised plan.

Table 3-4. Schedule for Covering or Upgrading In-Town Open Reservoirs

Reservoir	Open Reservoir Size (million gallons)	Covered Reservoir Size (million gallons)	Completion
Bitter Lake	22	22	2003[1]
Lake Forest Park	60	60	2003[1]
Lincoln	20	12	2006
Myrtle	7	5	2007[3]
Beacon	61	50	2008[3]
Roosevelt	50	0	2015[3]
West Seattle	68	30	2010[3]
Maple Leaf	60	60	2013[3]
Volunteer	20	0 or 10[2]	2015[3]
Total	369	239	

1 Floating cover, but likely to be replaced with buried storage at end of useful life of floating cover (about 20 years).

2 Although modeling shows that the benchmark emergency scenarios can be met without storage at Volunteer, a decision to decommission the reservoir site has not been finalized. The decision requires further operational experience to determine the importance of the reservoir to normal system operations. If a new, covered reservoir is constructed, the likely size would be 10 million gallons.

3 Estimated date of substantial completion.

The table shows that the Roosevelt Reservoir will be decommissioned and that some of the new reservoirs will be significantly smaller than the open reservoirs they replace. The Volunteer Reservoir may also be decommissioned rather than replaced. Using the methodology described in the *2001 Water System Plan*, SPU performed additional modeling of emergency scenarios to verify that the reduced storage is adequate for future needs. Also, the system will be operated with the Volunteer Reservoir taken off line for a length of time to verify that it is not needed for normal system operations. If that proves to be the case, the Volunteer Reservoir will be decommissioned.

Open Reservoir Protection Plan

In order to ensure that the quality of treated water is not diminished during its residence in open reservoirs, SPU operates and maintains its open reservoirs in accordance with a WDOH-approved, open reservoir protection plan. This plan includes provisions for reservoir maintenance and operation, security, water quality monitoring at locations within the reservoir itself and just downstream of the chlorine addition, follow-up actions, and emergency response.

Water Quality Enhancements at Storage Facilities

Some of SPU's enclosed storage facilities were constructed with a common inlet and outlet, or were otherwise designed without considering the optimal water flow conditions needed to maintain water quality by avoiding stagnant conditions. SPU has been modifying its enclosed storage facilities to improve water-quality management. Upgrade methods include separation of inlets and outlets, installation of mixing systems, multiple level sample taps, and sodium hypochlorite injection points.

In-Town Reservoir Treatment

Additional chlorination is provided at some of SPU's in-town storage reservoirs to ensure that chlorine residual is maintained in the drinking water supply until it reaches customer taps. In most cases, the treatment involves addition of sodium hypochlorite to increase the residual chlorine. At some reservoirs, hypochlorite is generated on-site, while at other reservoirs it is delivered to the reservoir site. Open reservoirs that were using chlorine gas are being converted to sodium hypochlorite. All of the hypochlorite and chlorine gas equipment is in good condition. A list of the chlorination facilities is provided in the treatment facilities inventory in the appendices.

3.3.6 Distribution System Facilities

During the last few years, SPU has made an unprecedented number of changes to distribution system facilities to ensure that its retail customers receive high quality drinking water. SPU's water quality-related improvements in distribution system include:

- Requirement that manufacturers of ductile iron pipe adopt special quality control procedures to eliminate on-going taste problems that the linings of some new pipes were causing in the Seattle distribution system.
- Installation of innovative mixing systems in new reservoirs and standpipes to help ensure that disinfectant residuals are well distributed throughout storage structures, thereby preventing microbial growth.
- Development of an EPANET hydraulic simulation model of the system, which can also model water quality in the distribution system in support of operational and design decisions.

- Conversion of booster chlorination systems from pH-reducing chlorine gas to hypochlorite systems with a higher pH to reduce corrosion potential as well as safety and security concerns.

3.3.7 Operations

SPU operations ensure that its customers receive high quality drinking water.

SPU undertakes a number of activities to ensure that its customers receive high-quality drinking water. Operations activities include water quality monitoring, preventing or eliminating cross connections, water main testing and flushing, and storage reservoir cleaning. Each activity is summarized below.

Comprehensive Water Quality Monitoring Plan

An updated comprehensive monitoring plan was developed in 2006 and is included as an appendix. The Comprehensive Water Quality Monitoring Plan covers the entire water system, from the watersheds through the transmission and distribution systems to the customer taps. The monitoring plan addresses the following:

- Monitoring requirements under state and federal drinking water regulations.
- Future regulations, which are currently under development at the federal level.
- Non-regulatory monitoring, which SPU conducts for informational purposes and to assist in operating the water system.
- Sampling procedures.
- Managing laboratory information.
- All parameters, locations, and frequency of monitoring conducted by SPU.

Cross-Connection Control Program

SPU's cross-connection program is a joint undertaking with Public Health Seattle-King County (PHSKC). The program includes elements to isolate and disconnect cross-connections both on the customer's premises and off. The updated cross-connection control policy and procedures are included as an appendix.

New Water Main Testing

New mains are disinfected and tested per American Water Works Association standards as detailed in Section 7-11.3(12) of the City's *Standard Specifications for Municipal Construction*.

Distribution Storage Facility Mixing and Cleaning

A key to maintaining water quality after the treated water enters the distribution system is making sure that storage facilities are kept clean and free from contamination. SPU has reduced total coliform levels throughout its distribution system by increasing reservoir cleaning and turnover.

Storage Facility Cleaning. SPU ensures its in-town, open reservoirs are drained and cleaned at least annually to protect water quality. Cleaning employs high pressure cleaning equipment to remove algae and debris buildup; then the facilities are disinfected before they are put back into service. Table 3-5 summarizes the cleaning frequency and timing for SPU's open reservoirs.

Table 3-5. Annual Open Reservoir Cleaning Schedule

Open Reservoir	Spring	Fall
Roosevelt		X
Maple Leaf	X	
Volunteer	X	X
West Seattle	X	

SPU monitors water quality analytical results and customer complaints to identify trends that indicate that more frequent cleaning is necessary.

SPU also ensures that its enclosed storage facilities are regularly cleaned to ensure water quality protection. SPU's approximate cleaning frequency for closed storage facilities is shown in Table 3-6. These cleaning frequencies may be adjusted based on inspections. Facilities that store Cedar water are on a more frequent cleaning schedule than those that receive Tolt water because the Cedar supply is not filtered.

Table 3-6. Closed Storage Cleaning Schedule

Type of Reservoir	Frequency of Cleaning
Elevated tanks or standpipes	3 years - Cedar supply 25 years - Tolt supply[1]
Hard-covered reservoirs	3 years - Cedar supply 25 years - Tolt supply[1]
Floating covered reservoirs	25 years – Tolt supply[1]
Floating covers (top of cover only)	Annually

[1] Assumes a 5-year inspection frequency

Water Main Flushing

The primary objective of SPU's water main flushing program is to improve water quality in the water distribution system and to reduce customer complaints regarding discolored water and unacceptable taste and odor. SPU has a program to perform both reactive and preventive water main flushing.

In 2005, under a pilot program, SPU began testing unidirectional flushing to bring water through the system in a controlled fashion at velocities sufficient to scour the distribution piping. The technique consists of isolating a particular section or loop, typically through closing appropriate valves, and exercising the hydrants in a sequential manner, progressing from the water source to the periphery of the system, from large-diameter to smaller-diameter pipes, and always from cleaned sections to dirty ones. System- or zone-wide unidirectional flushing is proactive, and its benefits can be long-term in nature. SPU will be evaluating the results of its unidirectional flushing pilot program in the near future to understand better the costs vs. benefits and to make an informed decision as to whether or not the unidirectional approach should have a long term place in SPU's distribution system management.

3.3.8 Strategic Asset Management Plans for Water Treatment Infrastructure

SPU is developing a strategic asset management plan (SAMP) for drinking water facilities, including in-town disinfection facilities. This SAMP will describe the infrastructure, their operations and maintenance, relevant service levels, repair and replacement needs, data needs, and other relevant asset information.

3.4 Needs, Gaps, and Issues

SPU works diligently to maintain its excellent water quality and consistently meet federal and state regulations. In the past decade, SPU has made significant strides towards ensuring that its water is of the highest quality while meeting current and future regulations. In particular, SPU's recent completion of the Tolt and Cedar Treatment Facilities has significantly improved SPU's water quality. In addition, SPU's recent and planned activities to cover, bury, or decommission its open reservoirs also demonstrate SPU's efforts towards ensuring excellent water quality in its system.

There are always new challenges for SPU to confront as it strives to meet its high standards for drinking water quality. The following sections summarize the needs, gaps, and issues facing the Water Quality and Treatment business area and describe SPU's plans to address them.

3.4.1 Future Regulatory Changes

The federal government is expected to pass a number of new water quality regulations over the next several years. These include the radon rule, which was originally proposed in 1999, the groundwater rule for which the U.S. Environmental Protection Agency (EPA) is expected to issue a final rule in August 2006, and revisions to the total coliform rule and lead and copper rule. These future regulations and their expected impacts on SPU are summarized in Table 3-7.

SPU will continue to stay informed on new water quality regulations and will develop plans to address issues that arise.

As noted in Table 3-7, the proposed radon rule, groundwater rule, and revisions to the total coliform rule and lead and copper rule could have minimal to moderate impacts on SPU's infrastructure and practices. Since the final form of the proposed rules and revisions and their impacts are still unclear, SPU plans to stay informed on the status of the rules. As the rules become clearer, SPU will develop comprehensive action plans to address any potential issues that arise.

Table 3-7. Future Regulations and Impact on SPU

Regulation or Issue	Provisions	Impact or Consideration
Radon Rule	Proposed both an MCL of 300 pCi/L and Alternative MCL of 4,000 pCi/L.	Seattle wells would require treatment or blending prior to supplying customers to comply with MCL, but they are currently below Alternative MCL. Blending would likely be the more economical alternative, but a final decision would need to be supported by a more detailed analysis. No radon detected in Tolt or Cedar.
Groundwater Rule	Proposed hydrogeologic assessment and possible source water quality monitoring and new treatment criteria.	Protected nature of aquifer for Seattle wells means that it is unlikely that new treatment requirements would be imposed.
Total Coliform Rule Revisions/ Distribution System Rule	Range of issues may be added or changed from indicator organisms and monitoring strategies to distribution system operation and maintenance.	Many issues are on the table for addition or revision in the rulemaking. All issues are of interest, but none are of severe major concern for SPU at this time.
Lead and Copper Rule Revisions	Near-term revisions likely to refine how compliance is demonstrated. Long-term issues could be more significant, including lead action level and lead in plumbing components.	Near-term revisions unlikely to have significant impact on SPU. Some adjustment may be needed to monitoring plan and schedule. Impact of long-term revisions could potentially be more significant, but changes not clear at this time.

3.4.2 Emerging Contaminants of Concern

New and emerging contaminants are continually being identified and researched by the scientific community. Currently, the EPA is evaluating contaminants on the second Candidate Contaminant List (CCL2) to determine whether these contaminants represent a health risk and, if by regulating a specific contaminant, a health risk would be minimized. Regulatory determinations are expected to be made on some of the contaminants by 2008. The CCL2 includes 42 chemical contaminants and 9 microbial contaminants.

The majority of the CCL2 contaminants present relatively low concern to SPU.

The majority of the CCL2 contaminants present relatively low concern to SPU because of its excellent source protection practices, state-of-the-art treatment facilities, and distribution system practices. One exception is the di-acid degradates found at very low levels in the Riverton Wells. Also, there are three microorganisms and one chemical on the list that are potential concerns because of their common presence in the environment.

The three microorganisms are *Mycobacterium Avium Complex (MAC), Aeromonas hydrophila,* and *Cyanobacteria*; and the chemical is aluminum. Although current treatment at the sources should provide an effective barrier to the microorganisms, the open reservoirs will provide an alternate route of entry until they are covered.

Without knowing which of these contaminants EPA will decide to regulate, or where it might set maximum contaminant levels, it is not known at this time what changes, if any, could be required of SPU in the future. SPU plans to continue monitoring the presence of these contaminants in the distribution system and participate and/or stay informed on national studies on occurrence, treatment, and health impacts. SPU also plans to stay abreast of EPA's regulatory determination on di-acid degradates planned for 2008. Finally, SPU is keeping informed on changes to EPA's process for developing the Candidate Contaminant List (CCL). Recent recommendations were proposed by the National Drinking Water Advisory Council on how to revise the CCL development process. These changes may be formally adopted by the EPA over the next several years.

Two additional emerging contaminants, MTBE and perchlorate, have received increasing national attention in recent years, but are not concerns for SPU. MTBE is a gasoline fuel additive that has been used since the late 1970s. Perchlorate is a strong oxidizer that is present in paints, oils, aircraft oxygen generators, flares, and other sources. There is a high likelihood that the EPA will propose to regulate perchlorate and MTBE in 2008. However, the impact of regulation on SPU will be low, since SPU's sources have no history of detectable levels of those contaminants, and there is little possibility of future contamination.

Also receiving increased attention, and not a concern for SPU, are endocrine disrupter chemicals (EDCs) and pharmaceuticals and personal care products (PPCPs). EDCs and PPCPs include drugs, hormones, preservatives in cosmetics, and other personal care product chemicals that have been detected in water supplies located downstream of wastewater discharges. None of SPU's water sources are downstream of any wastewater discharges, so these contaminants are not of concern to SPU water quality.

3.4.3 Water Quality at the Tap

While SPU delivers high quality drinking water to its customers' meters, concerns have grown about on-property water quality as a result of cross-connections and lead leaching in building plumbing.

These concerns arose as an issue in schools and have generated discussion about how SPU can best ensure that the public health and customer confidence objectives of its drinking water quality policy are adequately addressed.

SPU is evaluating additional initiatives to improve water quality at the tap.

SPU and PHSKC are jointly implementing a cross-connection control program as described earlier. SPU minimizes leaching of lead and copper from in-house plumbing through a corrosion control program, which includes pH and alkalinity adjustment. In its efforts to enhance public health and consumer confidence, SPU is evaluating additional initiatives to improve water quality at the tap. Some possible future programs that may be evaluated include:

- Modifying cross-connection control program to address emerging concerns like intrusion of residential gray water, reclaimed water, and water from rain barrels into the distribution system.

- Providing support to resolve lead concerns at schools and daycare centers.

- Supporting point-of-use treatment. This support could range from helping customers select treatment equipment to SPU maintaining treatment equipment under contract.

- Providing laboratory support in the form of services that could range from providing customers with a list of certified labs to offering free lab analysis of customer samples.

SPU plans to evaluate these initiatives and others using asset management techniques, including triple-bottom-line analysis, as well as customer willingness to pay surveys. Potential legal risks associated with taking actions that directly or indirectly affect private property will be given careful consideration as part of the evaluation.

3.4.4 Kerriston Road in the Cedar River Watershed

Kerriston Road is a King County road, about two miles of which are within the hydrographic boundary of the Cedar River watershed in the vicinity of Brew Hill. The road represents about 8 of the 230 acres of land in the watershed not owned by the City. WDOH has expressed concern about the potential public health and water quality impacts that could result from public use of the road. SPU proposes to conduct a comprehensive analysis of the risks presented by public access on the Kerriston Road to the Cedar River watershed. The analysis will include feasibility studies and cost estimates for all of the risk management options that are developed.

3.4.5 Lake Youngs Water Quality

Water quality in Lake Youngs has been changing in recent years, as evidenced by an increase in algal blooms and decreasing levels of oxygen at certain depths within the lake. As a result of the changes, there are concerns of deteriorating water quality in the lake, and in particular, increases in the amount of phosphorus and iron in the lake. As of yet, SPU is seeing only slightly increased concentrations of phosphorus in the Lake Youngs outlet, while iron levels show a definite upward trend. Phosphorus can result in more algal blooms. Additional data indicators such as clarity in the lake, total organic carbon, zooplankton counts, UV absorbance, and temperature have all shown changes. The exact cause of the water quality changes is still unclear.

SPU plans to address the changes in Lake Youngs water quality by further characterizing the lake and its constituents. In particular, SPU is currently in the process of implementing a monitoring plan which includes testing for dissolved organic carbon. Iron and manganese analysis will also be added to try to capture any patterns or trends in the water quality of Lake Youngs. Characterization of the lake will enable SPU to best address the water quality concerns through a well-informed mitigation plan, as necessary.

3.4.6 Well Field Readiness

The Riverton and Boulevard Well Fields provide important backup emergency supply and are available to supplement surface water supplies during moderate to severe drought conditions. Over the last fifteen years, the wells have been used infrequently. In the event of an outage of the Cedar source, the wellfield would be critically important to the continuance of supply because the wells are located in the part of the system that is most difficult to serve from the Tolt source.

While it is important for SPU to have backup water sources, several water quality-related factors complicate the start-up and operation of the wells, detracting from their value as emergency supplies. These complicating factors include:

- **Treatment.** Some of the treatment chemicals deteriorate over time and cannot be kept at the wells. Delivery of chemicals to the site can take three days, delaying start-up in emergencies. It is recognized, however, that in some emergency situations, untreated well water could be delivered to customers while the treatment processes and chemicals are being readied without short term regulatory consequences.

- **Blending.** Although the mineral content of the well water is relatively low for groundwater, it is significantly higher than for Cedar River water, which could present a problem for some commercial customers. To compensate, well water is blended with Cedar River water before it is delivered. If the Cedar River source were out of service, an emergency situation where the wells would play a crucial role, achieving the blending objectives becomes impossible.

- **Flushing.** When the wells have been inactive for an extended period, the first water pumped will be high in rust and sediment, and the well water must be diverted to the stormwater system for a few hours until the rust and sediment has been flushed out. Because of increased restrictions on the timing and rate of discharge to the area's drainage system, the disposal of flushing water has become more problematic.

- **Maintenance.** Routine maintenance at the wells is budgeted and performed to keep them in a state of readiness such that they can be activated within 14 days. This includes all of the mechanical, electrical, control, and treatment equipment. To have the wells in a higher state of readiness and available more quickly would require additional maintenance efforts and cost.

Because SPU considers the wells an essential component of supply to meet customer demand in the event of a Cedar outage, the Tolt/Cedar transfer improvements study, which is discussed in Chapter 4, will address the issue of well readiness as it relates to the time required to respond to a supply emergency. This study may lead to a detailed evaluation of the costs and benefits of continuing operation of the wells and formulation of a long-term strategy for the operation and maintenance of the wells.

3.5 IMPLEMENTATION/ACTION PLAN

With its construction of new treatment facilities, reservoir covering, and water quality management activities, SPU has accomplished a great deal since 2001. These actions have resulted in SPU meeting drinking water quality regulations and have placed SPU in position to continue to meet water quality requirements in the future. In addition, SPU has an ambitious list of important projects and actions in the Water Quality and Treatment business area that include the following:

- Continue implementing the open reservoir covering and replacement program; explore decommissioning of Volunteer Reservoir; provide written notice to WDOH by 2008 on the approach that will be used to meet the new requirements of the surface water treatment rule; submit and obtain WDOH approval on an updated reservoir covering plan by 2009.

- Stay abreast of EPA and WDOH regulatory development efforts and make adjustments as necessary to ensure that SPU's water quality service level is always met.

- Continue monitoring the science regarding new or emerging contaminants of concern, and continue to monitor source and finished drinking water to determine whether these contaminants are at levels of concern in SPU's supplies.

- Continue to evaluate approaches to helping SPU customers maintain excellent water quality in their own plumbing systems.

- Investigate management options for Kerriston Road to ensure that it does not threaten Cedar source water quality.

- Continue to monitor and characterize limnological conditions in Lake Youngs as it affects Cedar supply operations and raw water quality.

- Address the issue of readiness of Seattle Well Fields as it relates to the time required to respond to a supply emergency.

Chapter 4
Water Transmission System

Installation of the Tolt Transmission Pipeline

SPU's water transmission system consists of the large diameter pipelines, storage facilities, pump stations, and related infrastructure that convey raw water to the treatment facilities and treated water to the distribution systems of SPU's wholesale customers and its own retail service area. The water transmission system is part of the Transmission and Distribution business area. Proper management, operations, and maintenance of transmission system facilities ensures that SPU's wholesale and retail customers receive reliable and safe drinking water for consumption.

4.1 TRANSMISSION SYSTEM POLICIES

Management of the transmission system is guided by policies that SPU has developed. The first policy, the Transmission System Redundancy Policy, concerns SPU's process for making redundancy and retirement decisions for transmission system facilities and components. The second policy, the Access to Seattle Regional Water System Policy, concerns SPU's process for evaluating requests from other water purveyors to connect to SPU's transmission system.

4.1.1 Transmission System Redundancy Policy

Redundancy in the transmission system is one way that SPU can ensure reliability in delivering water to both its wholesale and retail service customers. While increased redundancy carries benefits of reduced or avoided customer outages, increasing transmission system redundancy adds capital and operation and maintenance (O&M) costs. Examples of redundancy include providing multiple ways of delivering water to a customer and having stand-by pumping capability or excessive water supply storage capacity. The purpose of this policy is to clearly establish the decision-making criteria that SPU uses for adding or retiring redundancy in the regional water transmission system.

SPU has not previously had a formal policy for transmission system redundancy. This policy was developed to incorporate asset management principles, primarily life-cycle benefit and cost analysis, into SPU's decision-making process regarding transmission system redundancy. This policy ensures that service reliability is considered along with costs when considering retirement of existing, redundant facilities or adding new facilities to increase redundancy. This policy will ensure that SPU invests in redundant infrastructure only when it is cost-effective over the long-term.

Policy Statement

Consider redundancy in the transmission system on a case-by-case basis, with decisions based on an evaluation of net present value.

1. *Consider retiring existing redundant facilities within the transmission system when they are at the end of their economic lives and the costs of a new replacement facility exceeds the avoided risks costs.*
2. *Consider adding redundancy within the transmission system when replacing facilities within the transmission system that have reached the end of economic lives or when performing repairs on existing facilities within the transmission system that require wholesale customer outages and the costs of redundancy are less than the avoided risks costs.*
3. *To increase redundancy, consider installing temporary or permanent looped systems, cross-over valves, intermediate line valves, and/or additional shut-off valves in the transmission system when the improvement provides positive net present value to the system.*
4. *When evaluating net present value of options over the life of the project, include the capital costs of installing the redundancy improvement and all O&M costs, such as those to repair the new facilities. Also include the benefits of any avoided risk costs, such as the costs of wholesale customer outages.*

4.1.2 Access to Seattle Regional Water System Policy

Like other water purveyors within the Puget Sound region, SPU is continuously evaluating its water system operations and the availability of water resources to ensure that it can meet future and emergency water demands. SPU and other providers in the region (e.g., Tacoma Public Utilities and Everett Water Department) have been discussing the benefits of being able to move water between regional systems to areas where it is needed for customer use or for in-stream needs in rivers or creeks. While there are obvious benefits of connecting regional water systems, there are also potential challenges in terms of potential drinking water quality and operational impacts.

In 2003, the Seattle Water Supply System Operating Board, whose membership includes representatives of Seattle and its wholesale customers, approved the *Access to Seattle Water System Guidelines* to provide guidance to SPU in reviewing another provider's request for access or connection to SPU water transmission system facilities. In accordance with the guidelines, SPU has developed an internal policy to guide decisions regarding access to its transmission system.

The Access to Seattle Water System Guidelines provide direction for reviewing requests to wheel water through the transmission system.

The Access to Seattle Regional Water System Policy is new and was written to formalize the *Access to Seattle Water System Guidelines* (included as an appendix) adopted by the Operating Board. Prior to the development of this policy, SPU was adhering to the guidelines. Before the guidelines were created, the decisions regarding system access were made on a case-by-case basis. As of the date of this plan, SPU has not approved any such connection to SPU's transmission system allowing water from another utility to be "wheeled" or moved through the Seattle regional water system.

Policy Statement

Evaluate requests for access to the Seattle regional water system using the Access to Seattle Water System Guidelines (Guidelines), based on the unique characteristics of the source that would be moved through the system.

1. *Consider options for full or partial access.*
2. *Weight drinking water quality and operational issues more heavily than other considerations.*
3. *Evaluate requests using asset management principles.*
4. *Update this policy as needed following any updates to the Guidelines by the Operating Board.*

4.2 SERVICE LEVELS

SPU has developed service levels that deal with the water service SPU provides to its wholesale customers. From a wholesale customer's perspective, the quality of water service can be measured by the amount of water flow provided, the pressure of that water, and the duration of any water system outages. Many of the drinking water quality service levels, as stated in the Water Quality and Treatment chapter, also apply to the transmission system. Table 4-1 summarizes SPU's service levels concerning service provision to wholesale customers.

Table 4-1. SPU's Service Levels for Managing Transmission System Assets

Service Level Objective	Service Level Target
Provide agreed-upon pressure and flow for wholesale customers.	Meet wholesale contract requirements for pressure and flow.
Limit drinking water supply outages.	Limit each unplanned outage in the transmission system to be within the maximum outage duration set for each pipe segment (24, 48 or 72 hours).

SPU is committed to meeting these service levels in its transmission system. Each of these service levels, including the rationale and current performance relative to the targets, are discussed below.

4.2.1 Pressure and Flow for Wholesale Customers

The current transmission system is capable of providing the pressure and flow rates called for in the wholesale contracts, and no incidents where SPU failed to meet its contract commitments have occurred in recent years.

SPU's contracts with its wholesale customers provide that customers can expect a specified minimum pressure at each wholesale service connection. The newer wholesale service contracts also specify the maximum flow rate at the given pressure that would be provided for each service connection. By agreeing on these limits, both SPU and its wholesale customers can adequately plan and operate their respective systems to deliver the service they promise to their customers. The current transmission system is capable of providing the pressure and maximum flow rates called for in the wholesale contracts, and no incidents where SPU failed to meet its contract commitments have occurred in recent years.

4.2.2 Wholesale Outage Duration

SPU has established a service level specifying a target for the maximum duration of an outage for wholesale customers. This service level demonstrates SPU's commitment to providing reliable water delivery services with minimal interruptions. Prior to this *2007 Water System Plan,* SPU did not have an established service level for continuity of service to wholesale customers, and none is stated in the wholesale contracts.

The water outage service level sets as a target a maximum duration of an outage for each transmission pipeline segment. SPU staff has conducted analysis of its transmission system components to determine the maximum amount of time it would take SPU crews to restore service to its wholesale customers in the event of an outage. The maximum outages range from 24 to 72 hours. A table with the maximum outage for each segment has been provided to the wholesale customers. The targets are based on site-specific conditions along each segment, such as the number of connections off of the segment, ease of access to the pipeline to make a repair, and type and size of pipe. To meet these targets, SPU will enhance its ability to make timely repairs to transmission pipelines by actions such as maintaining sufficient inventory of larger diameter pipe and fittings and standardizing and formalizing its response and repair procedures. Wholesale customers can use this information in planning and managing their distribution systems to prevent or reduce outages to their own customers.

There have been no outages to wholesale customers due to transmission pipeline failures since 1988.

There have been no outages to wholesale customers due to transmission pipeline failures since 1988.

4.3 Existing System and Practices

SPU's transmission system consists of the facilities that convey bulk water to wholesale customers throughout the regional service area, as well as to SPU's own retail service area distribution system. SPU's transmission system facilities include the large-diameter transmission pipelines, storage facilities, pump stations, wholesale customer meters, and other appurtenances that are used in conveying water from SPU supply sources to its wholesale customers and the SPU retail service area.

Since the *2001 Water System Plan*, the configuration of the transmission system has been modified to accommodate the construction of the two new treatment facilities. Cedar River source water is now pumped from Lake Youngs to the new Cedar Treatment Facility with its 180-million gallons per day (mgd) treatment capacity. Treated water from the treatment facility's clear wells flows to the four Cedar River pipelines for transport to wholesale customers generally east and south of Lake Washington, and to SPU's retail service area. A maximum of 200 mgd of treated water can be transmitted from the Cedar Treatment Facility through the Cedar River pipelines.

Source water from the South Fork Tolt Reservoir now flows to the Tolt Treatment Facility instead of directly into the transmission system. After treatment, transmission pipelines supply water to retail customers in the north part of the direct service area and to wholesale customers generally east and north of Lake Washington. The Tolt transmission facilities are capable of hydraulically delivering 135 mgd through the treatment facility and downstream transmission pipelines; the treatment capacity is 120 mgd.

4.3.1 Existing Facilities

A transmission system facility is considered part of the regional or subregional system if it serves more than one water purveyor. SPU's wholesale contracts define these systems.

The regional and sub-regional water transmission systems include 189 miles of pipeline, two open reservoirs (West Seattle and Maple Leaf), five covered reservoirs, 15 pump stations, and six elevated tanks and standpipes. Taps off of the major supply transmission pipelines from the Cedar and Tolt sources deliver water to wholesale customer master meters and intertie locations. Wholesale customers operate their own distribution systems serving their own retail customers. Brief descriptions of the elements that comprise transmission system infrastructure are presented below, along with assessments of the condition of related assets. An inventory of the primary transmission system facilities is provided in the appendices.

Pipelines

Of the 189 miles of transmission pipeline leading from the supply reservoirs to the distribution system, approximately 29 miles of pipe are categorized as "raw water pipelines" that convey untreated water from the supply sources to the treatment facilities. These pipes vary in size from 24 to 96 inches in diameter and are made of either steel or concrete. The remaining approximately 160 miles of transmission pipe transport treated water from the treatment facilities to SPU's wholesale and retail customers. These pipelines vary in size from 16 to 96 inches in diameter and are made of steel, concrete, or ductile iron.

SPU relies on the leakage history of its transmission pipes to provide an indication of condition. Leaks are identified by SPU crews that drive along the alignments of the transmission pipes weekly to look for water ponding on the surface. SPU's annual leakage rates for steel and concrete pipes, which comprise most of the transmission system, are 7.7 and 6.9 leaks per 100 miles per year, respectively. This is well below the national average for U.S. utilities of 25 leaks per 100 miles per year.

In addition to system modifications to accommodate the two new treatment facilities, the following major improvements have been made to the transmission system since the *2001 Water System Plan* to increase redundancy and improve performance:

- Tolt pipeline (TPL) No. 2, Phases II and III, completed the second Tolt pipeline between Redmond and Snoqualmie Valley, generally following a route separate from Tolt pipeline No. 1.

- TPL No. 2 – Phase IV completed the second Tolt pipeline between TESS Junction and Lake Forest Park Reservoir, and TPL No. 1 along this stretch was placed in stand-by mode at reduced pressure.

- TPL No. 1 rehabilitation and replacement, Phase IIIB, replaced the portion of TPL No. 1 in the Snoqualmie Valley.

- Mercer Island 16-inch line seismic retrofit upgraded the pipeline to resist movement during an earthquake.

- Blow-off improvements upgraded various facilities used to drain large transmission lines for maintenance.

- Renton line valve improvements on Cedar River pipelines 1, 2, and 3 installed new valves south of Augusta gatehouse per SPU's agreement with the City of Renton to minimize damage should a pipeline failure occur.

Storage

SPU owns, operates, and maintains 15 storage facilities in its transmission system. All store treated water. An assessment of the condition of these facilities is described below.

Reservoirs. Five of SPU's transmission system reservoirs are covered, and two are open reservoirs. Four of the five covered reservoirs (Eastside, Riverton Heights, Soos North, and Soos South) are prestressed or reinforced concrete tanks constructed between 1979 and 1990. Lake Forest Park Reservoir was constructed in 1961-62, and its structure consists of a hypalon-lined, reinforced concrete slab with a floating cover that was added in 2003. The structure of the two open reservoirs, Maple Leaf and West Seattle, consists of hypalon-lined, unreinforced concrete slabs. These reservoirs were constructed in 1910 and 1932, respectively. As described in Chapter 3, Water Quality and Treatment, these reservoirs are slated to be replaced with new, reinforced concrete, underground reservoirs.

The condition of the reservoirs is typically assessed by inspecting the structures, the embankment stability, the valves and piping, and any internal lining, and measuring the leakage rate from the reservoirs. SPU performs routine structural inspections of the tanks during cleaning activities to assess their condition and ensure that they meet regulatory requirements. Minor and major deficiencies are addressed through capital programs when they are identified.

Inspections revealed that the storage reservoirs are in good condition.

Inspections revealed that the storage reservoirs are in good condition. The internal lining of Lake Forest Park Reservoir was installed during its covering in 2003. The leakage rates from Maple Leaf, West Seattle, Soos North, and Soos South Reservoirs are low, under 0.12 gallons per minute per million gallons (gpm/MG). The leakage rates for Lake Forest Park and Eastside Reservoirs are 1.0 and 1.9 gpm/MG, respectively. Leakage tests were performed for these six reservoirs during 2003-2004, prior to the installation of the lining in Lake Forest Park Reservoir. In 2006, Eastside Reservoir underwent repairs to reduce its leakage rate.

Standpipes and Elevated Tanks. The SPU water transmission system includes five elevated tanks, one standpipe, and two control works surge tanks to provide drinking water storage. The elevated tanks and standpipes were constructed between 1925 and 1959. They range in capacity from 0.34 to 2 mg.

Tanks, including standpipes, are expected to have a service life of approximately 100 years with continued maintenance. SPU inspects the tanks visually to evaluate their condition and appearance. The condition of the tanks is evaluated based on the interior and exterior coatings, cathodic protection, valves and pipes, and the seismic upgrade status. The condition of each tank varies, depending on its year of construction and the year the last interior and exterior coatings were applied. Since there are some tanks that have not yet had seismic upgrades performed, and many tanks are nearing their next painting cycle, SPU has the following programs in place to improve their condition.

- **Seismic Upgrade Program.** The objective of the seismic upgrade program is to develop cost-effective mitigation solutions that protect SPU customers from loss of service and property damage following an earthquake. The program will include both physical hardening and non-hardening recommendations for various water facilities, including reservoirs, tanks, and standpipes.

- **Tank and Standpipe Recoating.** The tank recoating program involves safety modifications at tank sites, minor structural repairs, and interior and exterior surface preparation and coating following a regular maintenance cycle. The program includes nine standpipes and eight elevated tanks, some of which are part of SPU's distribution system. Some other tanks in the SPU water system will require some maintenance as well. Tank painting generally follows an approximate 15-year cycle. The timing will vary with need as shown by inspections and economic analysis.

SPU upgraded five of the elevated tanks (Richmond Highlands No. 1 and No. 2, Magnolia Tank, and Control Works NE and SW tanks) in 1993-1994. Myrtle No. 1 and No. 2 elevated tanks were upgraded in 2003. Beverly Park tank and Foy standpipe have not been upgraded yet. The net present value of upgrading both of these facilities will be assessed, and both facilities will be upgraded if deemed appropriate according to net present value analysis.

Pump Stations

SPU operates 15 transmission system pump stations. These pump stations are inspected regularly and equipment is repaired or replaced as needed. The only significant modification to the pump stations is occurring through the SCADA Valve Upgrade Project, in which SPU is installing position indicators for remote control valves in all of its pump stations. Aside from minor reconfigurations and component replacements/upgrades, there have been few changes to existing pump stations since the *2001 Water System Plan*.

The condition of SPU's pump stations varies depending on the age and condition of their components, their usage, past maintenance or rehabilitation activities, and other factors. SPU currently does not have a formal, structured process for deciding when an asset or component in a water pump station should be replaced or upgraded. Current practices determine replacement/upgrade schedules according to the expertise and opinion of SPU Field Operations Division staff. Pumps are monitored for efficiency and overhauled every 5 to 7 years.

4.3.2 Operations

Transmission system operations have been modified to accommodate the addition of the two new treatment facilities and new transmission system pipelines. Prior to 2004, water was diverted from the Cedar River at Landsburg into Lake Youngs through two supply lines. Water leaving Lake Youngs flowed by gravity through the Lake Youngs tunnel to the Control Works, where it was divided and sent into four major transmission lines. Two bypass pipelines allowed water to be diverted from

Landsburg directly into the transmission system, bypassing Lake Youngs. Lake Youngs Bypass 5 connected the supply lines to the Lake Youngs tunnel, bypassing just the lake. Bypass 4 connected the supply lines to the transmission system at the Control Works, bypassing not only the lake but the outlet tunnel as well. Finally, the Lake Youngs pump station pumped water out of the tunnel to supply Soos Reservoirs and two local water districts.

Transmission system operations have been modified to accommodate the addition of the two new treatment facilities and new transmission system pipelines.

When the Cedar Treatment Facility was built, most of the original bypass pipelines were converted to other uses. The upstream segments connected to the supply lines were left intact, retaining the ability to bypass Lake Youngs. The center segments were connected to the ozonation facility and serve as ozone contact chambers. The downstream segments of the bypass lines were connected to the clear wells, and now deliver finished water to Control Works.

The new clear wells raised the hydraulic gradient upstream of the Control Works by 24 feet. In order to prevent overflow at the surge tanks at Control Works, new flow control valves were installed on both finished water pipelines. The Lake Youngs pump station was relocated to one of the new flow control facilities.

Currently, water is pumped from Lake Youngs into the treatment facility and flows through the treatment processes by gravity to the clearwells. From the clearwells, flow to Control Works is through two finished water pipelines (FWP) and flow control facilities (FCF). FWP No. 4 and FCF No. 4 deliver water directly to Control Works through the old bypass 4 pipeline. FWP No. 5 and FCF No. 5 deliver water to the Lake Youngs tunnel through the old bypass 5 pipeline.

4.3.3 Maintenance

Proper maintenance of SPU’s transmission system components ensures that SPU will be able to deliver reliable water service, reduce the risk of unexpected failures, and provide safe drinking water quality to its wholesale and retail customers. SPU has prepared a number of strategic asset management plans (SAMPs) for each major class of transmission system infrastructure components. The SAMPs outline maintenance strategies for each asset. Summaries of those maintenance strategies are provided in this section.

Pipelines

Maintenance activities for water transmission pipelines include cleaning of exposed pipes and periodic inspections of pipelines. Moss and dirt are cleaned from exposed transmission pipes at least once every three years. Internal inspections are performed when pipes are emptied and out of service for repairs or maintenance, allowing inspectors to enter the pipe. External inspections are performed only when opportunities present themselves, such as when a pipeline is exposed for other work. An exception to this is the recent external inspections of the single line segment of the original Tolt pipeline No. 1 between the treatment facility and Kelly Road, and Cedar River pipeline No. 4. The purpose of these external inspections was to confirm that the concrete cylinder pipelines had not undergone significant deterioration since 1991, the date of the last inspections of concrete cylinder pipeline in SPU's transmission system.

Reservoirs and Tanks

Storage facility cleaning is performed to remove sediment, debris, and/or microbial growth. Cleaning is done on a scheduled basis or when water quality inside the storage has declined. The cleaning schedule is explained in the Water Quality and Treatment chapter.

Water Pump Stations

Maintenance activities at water pump stations ensure that the stations continue to operate with minimal failure, thereby reducing the likelihood of customer outage, loss of pressure, and potential introduction of pathogens into the distribution systems. SPU performs three types of maintenance activities for its pump stations as described below.

Preventative Maintenance. Preventative maintenance is maintenance which is carried out on a routine basis on elapsed time schedules or equipment run-time hours. Preventative maintenance is designed to eliminate routine failures. Table 4-2 lists typical preventive maintenance activities, the craft responsible for performing them, and the normal frequency at which those activities are performed.

Corrective Maintenance. When preventative maintenance tasks or other data indicate minor equipment malfunctions, corrective maintenance is performed. This type of equipment malfunction does not restrict normal operation of the pump station.

Table 4-2. Typical Pump Station Maintenance Activities

Craft	Task	Approximate Frequency
Carpenter	Building inspection	Annually
Electrician	Generator exercising	Monthly
Electrician	Pump motor starter maintenance	Every 6 mos
Electrician	Pump motor starter maintenance	Annually
Electrician	Valve operator	Annually
Mechanics	Overhaul pressure regulator	2 to 5 yrs
Mechanics	Flow meter inspect/overhaul	2 to 5 yrs
Mechanics	Diesel engine exercising	Every 2 mos
Mechanics	HVAC filter change	Every 2 to 3 mos
Mechanics	Air conditioner inspection	Annually
Mechanics	Pump station check	Twice weekly
Grounds	Basic site check	Weekly

Emergency/Reactive Maintenance. Emergency maintenance is generally carried out when a piece of equipment has failed and the need to restore its performance is critical. The criticality of each pump has been predetermined and incorporated into SPU's computerized work management system to ensure that repair of these facilities receives higher priority than other, non-critical repairs and that critical facilities are quickly put back into service.

Wholesale Customer Meters

SPU owns and maintains 126 wholesale water meters at intertie locations with wholesale customer systems that measure usage and provide a basis for billing wholesale customers. The most significant change to SPU's wholesale meters since the *2001 Water System Plan* has been the installation of radio frequency modules on almost all of the wholesale meter registers, which allow safer and faster meter reading by enabling the meters to be read without requiring personnel to enter the meter chamber. Meter installations that raise safety concerns, cannot be tested on site, or have older meters that are difficult to maintain are being replaced.

Wholesale customer meters are tested annually and maintained to meet accuracy standards.

Wholesale customer meters are 3 to 24 inches in diameter and classified as "large meters." SPU's policy is to install, test, and maintain all customer service water meters in such a way as to meet the accuracy standards of the American Water Works Association (AWWA). SPU's meter testing and maintenance practices are described below.

Meter Testing. Testing is performed annually on wholesale customer meters. SPU's meter testing practices include meeting standards of performance AWWA C700, C701, C702, C703; bench-testing all new large meters prior to installation to verify accuracy of meter lots; bench-testing all rebuilt internal assemblies; and field testing all new, exchanged, and repaired large meters.

Meter Maintenance. SPU performs scheduled maintenance activities on large meters based on a variety of criteria including manufacturer recommendations, AWWA standards and consumption history. Unscheduled maintenance activities are performed in response to billing questions and customer requests.

Meter Replacement. Meter replacement includes pipe work and vault modification necessary to bring meter installations up to current standards for accuracy, safety, and maintenance access, and to ensure that the impacts of supply interruptions due to meter maintenance and testing are maintained at levels that are acceptable to customers. Some upgrades may include relocation of the meter installation, and installation of Automated Meter Reading components. Meter replacements are discussed with the customer prior to scheduling to ensure current and future customer needs are met, as well as to ensure proper meter application and coordination to limit customer impacts. Reasonable efforts are made to coordinate meter upgrade work with local street improvement projects to minimize street cuts.

4.4 NEEDS, GAPS, AND ISSUES

SPU has completed a number of improvements to its transmission system since the *2001 Water System Plan* to improve transmission system reliability. In its continued effort to improve the quality of its services, SPU has identified several needs, gaps, and issues in regards to the transmission system. Needs include maintaining high water quality in the transmission lines, developing a strategy for maintaining, repairing, rehabilitating, and/or replacing transmission system pipelines, and enhancing transfer capabilities between the Cedar and Tolt supply sources. The following subsections summarize these issues and SPU's approach to addressing them.

4.4.1 Water Quality Issues in the Transmission System

Two water quality issues directly related to the transmission system include water quality in cement mortar-lined pipelines and covering the open tanks at the control works.

Water Quality in Transmission Lines

Large-diameter transmission pipelines composed of metal (e.g., steel, ductile iron, cast iron) are often lined with cement mortar to prevent corrosion and deterioration of the metal pipe wall. Lining transmission pipelines is a well-established practice nationwide; the benefits of which include increased pipe longevity, reduced risk of a pipeline failure, and consistent hydraulic performance. Ultimately, the practice of lining transmission pipelines provides SPU and its customers with cost-savings over the life of the transmission pipes. There are, however, water quality impacts of applying cement mortar lining to the interior of pipes.

Cement lining of pipelines can cause the pH in the water to increase.

Cement lining of pipelines can cause the pH in the water to increase (i.e. the water to become more alkaline or basic) when a section of pipeline is taken out of service for repair or maintenance but kept full of water. During extended contact between the water and the cement, calcium compounds can leech out of the cement and raise the pH of the water. Although pH is typically not a health issue until it becomes extremely low or very high, customers may find that water with moderately elevated pH tastes or feels different than that to which that they are accustomed. Additional customer concerns could include loss of aquarium fish, poor rinsing at car washes, or adverse impacts on other commercial and industrial facilities. Higher pH waters can impact other water quality parameters, such as increased formation of trihalomethanes and decreased effectiveness for chlorine disinfection.

The EPA-recommended lower and upper values for pH are 6.5 and 8.5, respectively. For the situations where water in transmission lines exhibits elevated pH, SPU establishes the following guidance:

- Water with pH up to 9.5 can be sent to the distribution system.
- If water in the pipeline has pH above 9.5, the pipeline will be flushed.
- In emergency circumstances, the SPU's Director may allow the pH 9.5 limit to be exceeded.

If future experience shows that the upper pH limit of 9.5 is inappropriate, this guideline will be revised.

Control Works Tank Covering

A separate, but water quality-related issue, is the lack of covers over the twin surge tanks at the Control Works. The openings are approximately 44 feet above ground level but contain treated water that is exposed to the open air. Options for covering the tanks are being investigated.

4.4.2 Pipeline Repair and Replacement

SPU's transmission system consists primarily of two types of pipe, distinguished by their material and their distinct modes of failure:

- Concrete cylinder pipe can have sudden, unexpected, and oftentimes very destructive failures.
- Steel and ductile iron pipelines usually develop increasing numbers of leaks that are detectable well before catastrophic failure.

Failure issues associated with each type of pipeline differ because their different failure modes and risks. The following section describes the failure issues for both types of pipes.

Concrete Cylinder Pipe

Concrete cylinder pipe (CCP) is manufactured by lining the interior of a thin-walled, steel cylinder with concrete mortar, then wrapping the exterior of the steel cylinder with steel reinforcing rod under tension. The entire exterior is then coated with concrete mortar to provide additional stiffness and corrosion protection. CCP derives most of its strength from the combined strength of the steel cylinder and the pretensioned rod reinforcing.

During the past several decades, CCP has received national attention from water professionals because of some sudden, unexpected, and often quite destructive failures. Unlike steel pipes, which typically exhibit leaks as they begin to fail, CCP failures are more often catastrophic in nature. CCP failures usually result from corrosion of the tensioned reinforcing rods. The steel cylinder itself lacks sufficient strength to withstand the pressure of the water inside the pipe. Should the tensioning rods corrode or deteriorate to the point where they no longer provide sufficient tension to hold the pipe together, the pipe cylinder can fail, sometimes producing explosive bursts of water.

SPU's only sudden CCP failure occurred in 1987 on the Tolt Pipeline No. 1 (TPL1). The failure caused significant flooding and property damage. Detailed investigations revealed that the failure was caused by a particular type of corrosion known as hydrogen embrittlement, where chemical reactions with hydrogen ions in the soil cause the steel to turn brittle and lose its strength. The chemical process is irreversible, and the only remedy is to replace the pipe or to use it as a casing and to install new, smaller-diameter, fully competent pipe inside. Only the steel that was used for the spiral wrap by one particular pipe manufacturer (United Pipe) was found to be susceptible to hydrogen embrittlement. In SPU's system, all pipe made by United and prone to hydrogen embrittlement has been either replaced or slip-lined with new steel or ductile iron pipe.

Investigations in the early 1990s revealed some deterioration of the rest of the CCP lines; however, no CCP failures have been experienced since the 1987 failure. The absence of additional CCP failures and condition assessment reports invariably lead to the conclusion that SPU's remaining CCP are in a somewhat deteriorated but still serviceable condition. In an effort to mitigate further deterioration of CCP, SPU piloted a cathodic protection project. Cathodic protection has the effect of reducing the rate of metal corrosion in pipelines. The pilot installation proved successful and showed that a single deep cathodic protection well can protect about one mile of concrete cylinder pipe with fairly even electric potential distribution. The pilot project indicates that the risk of CCP failures can be well-mitigated by cathodic protection efforts.

Cathodic protection is a method employed to minimize the rate of electrochemical corrosion of metallic materials, such as pipes.

In the *2001 Water System Plan*, SPU had conservatively planned to replace all of its CCP with steel pipelines in its 25-year Capital Facilities Plan. In light of SPU's completed replacement of all hydrogen-embrittlement prone CCP, condition assessments, and cathodic protection pilot study, SPU no longer believes pro-active replacement, or even slip-lining, of all its CCP to be necessary. Rather, SPU's new, long-term strategy for managing CCP is as follows:

- Maximize the use of cathodic protection to extend the service life of CCP well into the future and continuously assess its effectiveness in arresting corrosion.

- Maintain and enhance SPU's capability to identify pipe failures with pressure sensing and isolate them quickly so as to minimize property and environmental damage arising from the uncontrolled release of water.

- In the unlikely event that a failure does occur, plans are in place to respond expeditiously and repair the pipe and place it back on line, as provided in the outage service levels.

- Stay current on new pipeline inspection technologies. When high tech tools and methods for non-destructive, no-dig condition assessment for this particular type of concrete cylinder become available, they could be used to inspect pipe sections. After such inspections, SPU can apply asset management principles to decide if any should be replaced.

Steel and Ductile Iron Pipe

Steel and ductile iron pipelines differ significantly from CCP in that they develop increasing numbers of leaks well before catastrophic failure. In most cases, leaks can be repaired without depressurizing or taking the pipeline out of service. An aging steel pipeline is more likely to present an economic concern due to its increasing repair costs well before its structural strength is imperiled.

When the incidence of leaks on a steel pipeline starts to increase, installing cathodic protection can stop further increases. SPU has used cathodic protection, coupled with internal cement mortar relining, on numerous sections of steel pipelines where either significant leaks have been experienced in the past or may be expected in the future due to corrosive soils. At this time, SPU experiences a very low leak rate on its steel pipelines.

In the *2001 Water System Plan,* in light of the Tolt pipeline failure event in 1987, the 25-year Capital Facilities Plan assumed replacement of major portions of the older steel pipelines would be required. No specific locations were identified, although significant funding per year for more than a decade was included in the Capital Facilities Plan. The very low level of leaks currently experienced, the minimal damage produced by these leaks, the success of the cathodic protection program, and the fact that, in most cases, steel pipelines can be repaired while remaining in service all suggest that massive replacement of steel pipelines over the next 30 years is not necessary. Cathodic protection is a viable alternative to replacement along higher risk areas, like steep slopes or near critical utilities and transportation corridors where an undetected leak may result in high damage costs and where replacement costs are high.

4.4.3 Cedar/Tolt Transfer Improvements

During normal operations, SPU's two major supply sources, the Cedar River and the South Fork Tolt River, each supply portions of SPU's service area. The Cedar generally provides water to the southern and central portions, and the Tolt generally provides water to the northern portions of the service area. During emergency or unusual circumstances, it may become necessary to use one source of supply to provide water to areas of the system to which it would not normally provide water. These circumstances could include water quality or source water production problems at one supply source, increased demand in one portion of the system, or greater need for operational efficiency during critical periods.

Cedar/Tolt transfer improvements study will evaluate options to increase flexibility of using water from each source.

In an effort to maximize the reliability and flexibility of the transmission system, SPU is investigating opportunities to improve transmission and SCADA infrastructure as well as operations to facilitate more reliable transfer of Cedar source water to the northern portions of the regional system, and Tolt source water into additional southern portions of the service area. The goals of this study are to improve understanding through analysis and/or testing of actual and perceived system/operational boundaries and constraints; understand clearly the costs, risks and service level implications of pushing boundaries, where appropriate; and recommend the best use of SPU supply and transmission assets to avoid, manage or mitigate unusual and emergency conditions at the lowest life-cycle cost.

4.5 IMPLEMENTATION/ACTION PLAN

As described earlier, the primary issues facing the transmission system include water quality issues from concrete mortar linings in new transmission piping and having uncovered tanks at the Control Works, replacement and/or rehabilitation of aged steel and concrete cylinder pipe, and enhancement of the transfer capabilities for the Cedar and Tolt supply sources. To address those and other issues discussed in this chapter, SPU has identified the following major implementation and action plan items:

- Maintain and operate the transmission system to meet the pressure and flow service level targets and pH guidelines.

- Complete preliminary engineering, design, and construction of covers for the Control Works surge tanks.

- Continue to implement cost-effective cathodic protection projects for the CCP and steel transmission pipelines to extend their service lives well into the future; continuously monitor the effectiveness of cathodic protection in arresting corrosion; and stay abreast of new technologies for non-destructive, no-dig condition assessment for CCP.
- Enhance SPU's transmission pipeline repair capability and manage outage durations in the transmission system pipelines to meet service level targets.
- Complete the Cedar/Tolt transfer improvements study and implement improvements with positive net present value to allow greater flexibility in using water from each source.

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Chapter 5
Water Distribution System

Water meter

This chapter focuses on the SPU water distribution system, the part of the Transmission and Distribution business area that involves delivery of water for retail use and for fire flow. SPU's water distribution system consists of water mains, distribution storage facilities and pump stations, and related appurtenances such as valves, hydrants, service connections, and retail billing meters. The supervisory control and data acquisition (SCADA) system used to monitor and control the water system is also discussed in this chapter. Proper management of the distribution system ensures that SPU meets its service levels for retail customers.

5.1 Water Distribution System Policies

SPU developed the following new policy to describe SPU's decision-making process and criteria for addressing redundancy in the distribution system.

5.1.1 Distribution System Redundancy Policy

Redundancy in the distribution system is one way that SPU can increase the reliability of water delivery to its retail service customers. Distribution system redundancy is provided by the network of water mains, appropriately spaced valves, stand-by pumps, and storage, all of which can help minimize customer outages. Increasing redundancy, however, adds capital and operation and maintenance (O&M) costs that may not necessarily be justified. This policy was developed to incorporate asset management principles, primarily life-cycle benefit and cost analysis, into SPU's decision-making and clearly establish the criteria that SPU will use for adding or retiring redundancy in its water distribution system. This policy ensures that service reliability is considered along with costs when considering retirement of existing redundant facilities or adding new redundancy. In developing this policy, SPU aimed to balance the consequences and costs of failure with the benefits of redundancy. It favors adding redundancy only when it is cost-justified - meaning the benefits outweigh the costs.

Net present value (NPV) compares the value of a dollar today to the value of the same dollar at some time in the future by accounting for inflation and interest.

Policy Statement

Consider redundancy in the distribution system on a case-by-case basis, with decisions based on an evaluation of net present value.

1. *For new developments or redevelopments within the distribution system, require developers to install looped systems, intermediate line valves, and/or additional shut-off valves for dead-end water mains when SPU determines that the improvement provides a positive net present value to the water system in the area.*
2. *Consider retiring existing redundant facilities within the distribution system when they are at the end of their economic life and the costs of a new facility exceeds the avoided risks costs.*
3. *Consider adding redundancy within the distribution system when replacing existing facilities that have reached the end of their economic life or when performing repairs on existing facilities that require retail customer outages.*
4. *To increase redundancy, consider installing temporary or permanent looped systems, cross-over valves, intermediate line valves, and/or additional shut-off valves in the distribution system when the improvement provides positive net present value to the system.*
5. *When evaluating net present value of options over the life of the project, include the capital costs of installing the redundancy improvement and all O&M costs such as those to repair the new facilities or to flush any dead-end mains. Also include the benefits of any avoided risk costs, such as the costs of retail customer outages and temporary loss of fire flow.*

5.2 SERVICE LEVELS

SPU developed service levels to manage its water distribution system assets and describe what retail customers can expect of SPU in terms of water pressure and problem response. Also, a service level was developed to limit the amount of water lost to leakage. Many of the drinking water quality service levels, as stated in the Chapter 3, also apply to the distribution system. Table 5-1 summarizes the distribution system service level objectives and targets used by SPU to manage its distribution system assets. In addition to the service levels listed below, SPU is developing a service level target for limiting drinking water supply outages to retail customers.

Table 5-1. SPU's Service Levels for Managing Distribution System Assets

Service Level Objective	Service Level Target
Provide adequate pressure for drinking water supplies.	• New or expanded parts of the distribution system designed to deliver peak hour demand at a minimum of 30 pounds per square inch (psi) at the meter. • No retail customers with less than 20 psi during normal operations.
Respond quickly and effectively to water distribution system problems.	• 80% of distribution system problems (emergency situations such as a pipe break; potential contamination of water supply; hydrant damage) responded to within 1 hour.
Meet water use efficiency goals to ensure wise use and demonstrate good stewardship of limited resource.	• Distribution system leakage losses of no more than 10% of total supplied to the retail service area, as defined by Washington Department of Health guidelines.

Each of these service levels, including the rationale and current performance relative to the targets, are discussed below.

5.2.1 Distribution System Pressure

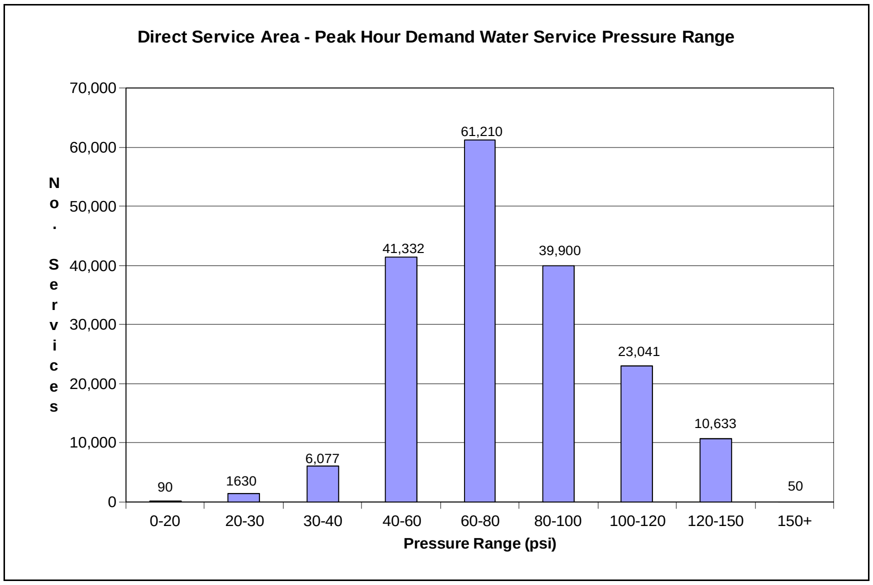
Water pressure is the force of water, expressed in pounds per square inch, available from the water system.

Maintaining adequate distribution system pressure is critical to ensure both customer service and drinking water quality. Adequate water pressure enables customers to have sufficient water flow from their household plumbing fixtures and appliances. In addition, adequate pressure prevents contaminants from entering the distribution system through pipeline leaks and cross connections.

In 2004, SPU developed a service level which meets Washington State Department of Health (WDOH) requirements for pressure and provides a method for an economic analysis of supplying higher pressure levels in new and existing areas of the distribution system. This service level establishes a minimum 20 pounds per square inch (psi) service connection pressure standard for the existing distribution system during normal operations and a minimum 30-psi design standard for new distribution system construction, consistent with the Washington Administrative Code (WAC). Current services with less than 20 psi of pressure will be brought up to at least 20 psi through system improvements. Existing services with pressures less than 30 psi will be brought up to a higher pressure when it is economical to do so.

More than 99 percent of SPU water services provide at least 30 psi during normal and peak hour demand periods.

Figure 5-1 shows the overall range and frequency of service pressures within SPU's direct service area based on hydraulic modeling of the entire system. More than 99 percent of SPU water services provide at least 30 psi during normal and peak hour demand periods. Plans to raise pressure at locations with less than 20 psi are described later in this chapter.



* Note: Based on hydraulic network modeling using peak day operational data from 1998, with water demands increased by 5%. This is equivalent to a total system consumption of 277 mgd, which is not forecasted to occur until sometime after 2060.

Figure 5-1. Range of Water Pressure within SPU's Distribution System*

5.2.2 Response to Distribution System Problems

Although distribution system problems are infrequent, their occurrence requires a timely and effective response to ensure that water service is restored and safe drinking water is delivered. SPU's problem response service level provides that for 80 percent of potentially high priority distribution system problems, SPU crews will be at the site within 1 hour of SPU receiving a telephone call with notification of the problem. High priority problems are those that potentially present an immediate public health or safety concern, and include pipe breaks, hydrant damage, or potential contamination of the water supply.

Using its computerized maintenance management system, SPU tracks high priority problems reported in the retail service area and how long it takes crews to be on site and begin resolving the problems. During 2005, SPU responded to more than 80 percent of high priority problems within 1 hour.

5.2.3 Leaks

While some level of leakage is unavoidable, it is important to SPU to keep leakage to a minimum because it represents a waste of valuable resources and may result in water damage to property. WDOH is developing a requirement that would limit distribution system losses from all leaks to 10 percent of the total water delivered to the retail service area. SPU intends to meet the WDOH requirements with this service level.

Leakage is only one component of non-revenue water.

SPU's water system has had a history of low leakage rates. In 2005, SPU's total non-revenue water was 9.3 million gallons per day (mgd), or 7 percent of the total 128 mgd produced. Leakage is only one component of non-revenue water; other components include seepage and evaporation from open reservoirs, water used for flushing and firefighting, as well as meter errors. Current leakage from SPU's distribution and transmission system is estimated at between 3.3 mgd and 4.8 mgd, or between 5 and 7 percent of the 67 mgd total produced excluding that sold to wholesale customers in 2005. Approximately 15 percent of the leakage comes from transmission pipelines and water mains, and the remaining 85 percent comes from service connections on SPU's side of the meter.

5.3 EXISTING SYSTEM AND PRACTICES

The water distribution system consists of the facilities that deliver treated water to SPU's retail water customers.

The water distribution system consists of the facilities that deliver treated water to SPU's retail water customers. Distribution system facilities include water mains, storage facilities, pump stations, retail customer meters, and other appurtenances. The water distribution system contains more than 1,600 miles of water mains, most of them 6 to 12 inches in diameter. Seattle's water distribution system also includes two open reservoirs, seven covered reservoirs, 15 pump stations, and ten elevated tanks and standpipes. In addition, the City has more than 180,000 service lines and meters serving individual residential and non-residential properties.

Since the *2001 Water System Plan*, major improvements in the distribution system have included covering Bitter Lake and Lincoln Reservoirs as described in Chapter 3. Burying of Beacon and Myrtle Reservoirs began in 2006, and the Queen Anne Tank and Pump Station Projects are being implemented. Numerous water main improvement projects have also been completed in conjunction with redevelopment and other agency projects, such as Sound Transit transportation projects. SPU has also proactively replaced plastic service lines, due to the high rate of failure for this pipe type, where it was economical to do so. In addition, a new SCADA system has been placed into service.

The following sections provide a description of the major classes of distribution system assets and a brief summary of their condition. The distribution system facilities O&M practices are also described, with attention given to changes in these practices or facilities since the *2001 Water System Plan*.

5.3.1 Existing Infrastructure

A description of the major components of SPU's water distribution system, a summary of their condition, and SPU's replacement/ renewal strategy is summarized below. A detailed inventory of the major asset classes is provided as an appendix.

Water Mains

Seattle owns a network of 1,641 miles of water mains within its retail service area. Since the *2001 Water System Plan*, many water main improvement projects have been completed, with a number completed in conjunction with re-development and other agency projects, such as Sound Transit transportation projects. However, the overall configuration of the distribution system remains unchanged since 2001.

The condition of SPU's water mains varies based on a number of factors including age, material, size, date of installation, and site specific conditions such as soil type and water table depth. The years of installation of distribution water mains is shown in Figure 5-2.

SPU does not have specific condition assessment information for most of the distribution system, since inspections are performed only following pipe breaks. Without specific condition assessment data, the most appropriate measure of condition of the water mains is the leakage rate. Based on data from 1995 to 2005, the leakage rate of water mains is low, averaging approximately 8 reported leaks per 100 miles per year in the distribution system. This is less than half the rate of other major water utilities in the western United States. SPU's total water loss from water mains is estimated to be approximately 0.5 to 0.7 million gallons per day, or between 300 to 430 gallons per day per mile. The International

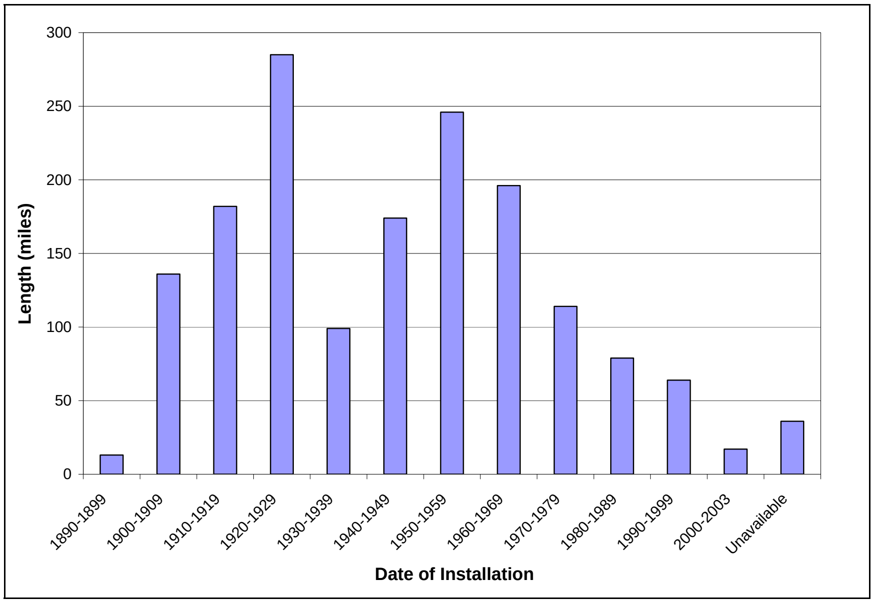


Figure 5-2. Year of Installation of SPU's Distribution System Water Mains

As a result of SPU's ongoing water main replacement program, SPU's water main break rate dropped from approximately 12 to 8 breaks per 100 miles during the past decade.

Water Agency (IWA) estimates that water loss from water mains should be approximately 370 gallons per day per mile for a well-run utility.

Water mains continue to be replaced as part of SPU's ongoing water main replacement program, which replaces leaking pipelines at the most economical time. During the 1990s, SPU proactively replaced a number of galvanized iron water mains that were exhibiting higher break rates than pipes of other materials. As a result of this program, SPU's water main breaks per 100 miles per year dropped from approximately 12 to 8 during the past decade.

Tuberculation is the development of small mounds and growths of corrosion (rust) inside of pipe.

Approximately 700 miles (43 percent) of The City's water mains are composed of unlined, cast iron pipes. As these pipes age, many of them exhibit varying degrees of tuberculation, small mounds and growths of corrosion (rust) inside of pipe. Tuberculation increases the pipe wall roughness inside of the pipe, thereby increasing resistance to water flow which reduces pipe flow capacity, increases pumping costs, and causes water quality problems such as discoloration, low chlorine residuals, and taste and odor problems. SPU is completing a pilot project to clean and apply cement mortar lining to restore these pipes at a fraction of the cost of replacing them. Since cleaning and lining work generally does not require pipeline excavation, there is less disruption to the community than with pipe replacement. If this pilot project is successful (i.e., if it is cost effective, improves water quality, improves flow, etc.), SPU will establish a long-term program to apply this lining to the unlined cast iron pipe in the distribution system.

Distribution System Water Storage Facilities

SPU's distribution system includes eight in-city reservoirs and ten elevated tanks and standpipes to provide regulating and backup storage capacity to its retail customers.

Distribution System Reservoirs. The City of Seattle owns and SPU operates and maintains eight reservoirs in the distribution system. Bitter Lake was retrofitted with a liner and floating cover beginning in 2001, and Lincoln Reservoir was reconstructed as a buried reservoir beginning in 2004. The Beacon and Myrtle reservoir replacement projects began in 2006, when the existing reservoirs were taken out of service. SPU is investigating the possibility of retiring the last two open reservoirs, Volunteer and Roosevelt.

Condition assessment of in-town reservoirs follows the same procedure as described for the water transmission system reservoirs. Based on inspections, the structures are in good condition. Roosevelt's high-density polyethylene liner was replaced in 1990 and, with an estimated life expectancy of 20 years, is not likely to need replacement before the reservoir is decommissioned. Volunteer, View Ridge, and Magnolia Reservoirs are unlined. The leakage rate from Bitter Lake, Roosevelt, and Magnolia Reservoirs is low, measured in 2003-2004 at under 0.6 gallons per minute per million gallons (gpm/MG). The 2003-2004 leakage rates for Volunteer and View Ridge Reservoirs were 3.5 and 2.6 gpm/MG respectively. Leakage from Lincoln Reservoir was tested during construction and found to be minimal and within acceptance criteria.

Distribution System Elevated Tanks and Standpipes. In addition to its in-town reservoirs, the SPU water distribution system includes two elevated tanks and eight standpipes. The elevated tanks and standpipes were constructed between 1907 and 1996. They range in capacity from 0.88 mg to 1.40 mg. This excludes the Queen Anne standpipes, which are both scheduled for demolition in early 2007, and are planned to be replaced with a single 2-mg tank.

Distribution system tanks and standpipes are inspected and maintained in the same manner as transmission system tanks, as described in the Transmission chapter.

Distribution System Pump Stations

SPU operates 15 distribution system pump stations with a total of 32 individual pump units. These pump stations are inspected regularly to ensure that they continue to function properly and equipment is repaired or replaced as needed. The most significant change to SPU's pump station assets will be the addition of a new pump station on Queen Anne Hill. This pump station will feed a new pressure zone that is expected to address low-pressure problems experienced by customers. Another modification to the pump stations is occurring through the SCADA Valve Upgrade Project, in which SPU is installing position indicators for remote control valves in all of its pump stations to help with system operations. Aside from minor reconfigurations and component replacements/upgrades, there have been few changes to existing pump stations since the *2001 Water System Plan*.

Distribution system pump stations are maintained in the same manner as transmission system pump stations, as described in the Transmission chapter.

Distribution System Appurtenances

Distribution appurtenances include various parts, features and elements that are incidental, integral, or subordinate to the system, such as valves and hydrants.

The SPU water distribution system includes a number of smaller appurtenances, such as valves, hydrants, service lines, and meters. The paragraphs below summarize SPU's inventory and replacement approach for each class of appurtenance.

Distribution System Valves. SPU's water distribution system includes more than 21,000 valves. More than 16,600 valves control the flow of water through the distribution system, but other valves regulate pressure, bypass other facilities, or allow air to escape the system. Most valves within the distribution system are gate valves. The only significant modification to SPU's valves planned since the *2001 Water System Plan* will be the valve chamber replacement program that will replace existing chamber tops and access maintenance holes with larger diameter tops and new access ladders. This program will provide SPU maintenance staff with safer valve chamber access and meet industry safety standards.

SPU has an ongoing program to replace line valves when they fail beyond repair, when no replacement parts are available, or where the cost of repair exceeds the cost of replacement. The determination of when a valve should be replaced instead of repaired is based on consultation among SPU staff experts.

Distribution System Hydrants. SPU maintains more than 18,350 fire hydrants. There are two classes of fire hydrants: in-service hydrants, which are considered suitable for fire fighting, and out-of-service hydrants. SPU maintains in-service hydrants based on inspections conducted by the fire service agency that serves the area. While out-of-service hydrants are not suitable for use in fire fighting, either because they are not in good repair or because the water supply is not adequate for fire fighting, those hydrants may still be used for water main flushing. SPU paints the out-of-service hydrants white to distinguish them from in-service hydrants. SPU maintains the out-of-service hydrants based on information provided by its field personnel. There have been few changes to fire hydrants since 2001.

SPU's hydrant replacement strategy is to take advantage of opportunity projects to replace obsolete hydrants in areas where excavation costs are low and future costs are likely to be much higher. Other than these opportunity projects, SPU replaces hydrants that are found to be not operable, and replaces obsolete ones. New hydrants may also be installed as part of new development.

Distribution System Service Connections. SPU maintains approximately 180,000 service connections, 80 percent of which are ¾-inch diameter pipes. Almost 70 percent of service connections are copper, and 20 percent are plastic. The remaining 10 percent are galvanized iron, ductile iron, and other materials. The most significant change to SPU's service connections since 2001 is the initiation of a program to proactively replace non-copper service connections with copper connections. This program is intended to reduce the high leakage and failure rate of non-copper service connections and is expected to be complete by 2015.

By proactively replacing non-copper service connections with new copper connections, SPU expects to reduce leakage rates.

The most appropriate assessment of the condition of SPU's service connections is their leakage rate. In 2005, SPU's leakage rate from its service connections was approximately 2.8 leaks per 1,000 service connections. This is lower than the IWA's target leakage rate of 3.75 leaks per 1,000 service connections for a well-run utility. The current volume of leakage from SPU's service connections is estimated between 2.8 to 4.0 million gallons per day (mgd), or between 15 to 22 gallons per day per service connection. IWA's target leakage volume is approximately 15 gallons per day per service connection. SPU's non-copper service connections have leakage rates that are greater than 5 leaks per 1,000 service connections. By proactively replacing these non-copper service connections with copper connections, SPU expects to reduce the service connection leakage rate down to 1.5 leaks per 1,000 service connections, well below the IWA target. For all other copper services, SPU's replacement program is a "run-to-failure" strategy, since the impacts of a failed copper service are typically minor, and the services can be quickly replaced.

Distribution System Meters. Each service line is fitted with water meters used to determine customer charges. Most of the meters (87 percent) are for residential customers, and the remaining 13 percent are for commercial customers. Nearly 92 percent of SPU meters are small (3/4-inch and 1-inch). Since the *2001 Water System Plan*, the most significant change to distribution meters, other than routine meter replacements and repairs, has been the installation of radio frequency modules on difficult-to-read meters in the downtown area. Also, radio frequency modules were installed in 2005 at a group of multi-family residential meters to pilot-test a new technology to collect readings from a single pole-mounted collector.

5.3.2 Distribution System Operation

SPU's water distribution system is primarily served by gravity. For pump stations, valves, and other system components, SPU's SCADA system provides remote control and information feedback to system operators.

SPU operates its water system through its SCADA system. From the control room in the Operations Control Center, SPU water system operators use the SCADA system to remotely control facilities such as pumps and valves. The SCADA system provides real-time data regarding pressure, flow, storage facility water level, and pump/valve status to system operators. Archived SCADA data are also useful for hydraulic network modeling, system planning, and engineering design.

SPU has replaced its obsolete tone-telemetry system with a modern PC-based digital system. The operator interface moved from the 50-foot "big board," where data was displayed on strip charts and light-emitting diodes (LED) readouts, to a personal computer-based system in early 2006. In addition to providing a uniform interface and allowing for automated data collection, this change has removed the limitation for expanding the number of SCADA remote sites. The new SCADA system is among the first post-"9/11" systems, utilizing a balance of physical and cyber security features. A backup control room has been constructed at the SPU North Operations Center to provide redundant system monitoring and control.

SPU is in the process of expanding the number of sites monitored and controlled by SCADA as well as enhancing how the SCADA data is used for system operations and planning. The first phase of SCADA expansion will be completed in 2008-9, and the second phase will start in 2010. An expanded SCADA system will allow SPU to better serve customers through improved service level monitoring and reduced operational risks.

5.3.3 Distribution System Maintenance

SPU has prepared a number of SAMPs for each major class of distribution system infrastructure components.

Proper maintenance of distribution system components ensures that SPU will be able to deliver reliable water service, reduce the risk of unexpected failures, and provide safe drinking water quality to its customers. SPU has prepared a number of strategic asset management plans (SAMPs) for each major class of distribution system infrastructure components. The SAMPs outline maintenance strategies for each asset. Summaries of those maintenance strategies are provided below.

Water Mains

Water mains located at "dead-ends" or with low flows often accumulate sediment or have the potential for microbial growth. SPU crews flush low-flow or dead-end mains to maintain water quality. SPU has also begun a pilot unidirectional flushing program, as described in the Chapter 3.

Reservoirs and Tanks

Storage facility cleaning is also performed to remove sediment, debris, and/or microbial growth as described in Chapter 3.

Water Pump Stations

Pump stations in the distribution system are maintained in the same manner as described for the transmission system pump stations, as described in Chapter 4.

Water Appurtenances

SPU also performs maintenance activities for its valves, hydrants, service lines, and meters to ensure their continuing operation. A brief description of each follows.

Valves. SPU responds to an average of 100 valve-related problems per year. Most valve problems can be categorized as leaks, casting failures, mechanical inoperability, and valves being buried by new pavement. Deterioration of interior packing, broken and bent stems, and construction projects are usually the causes of valve problems.

SPU is responsible for operating and exercising distribution line valves. Large valves, those 16 inches or larger, were exercised and inspected by valve crews annually until 2003. Due to shifts in priorities, this routine operation work is performed less frequently.

Hydrants. Each fire service agency inspects hydrants located within its service area, generally on an annual basis. Defects are reported to SPU for repair. During a twelve month period in 2002-2003, SPU responded to approximately 2,269 work orders to address fire hydrant defects. During maintenance visits, SPU paints hydrants to prevent exterior corrosion and improve their appearance. The average hydrant painting interval is approximately five years.

Service Connections. SPU spends about $1.2 million annually on reactive maintenance and repair of water service lines extending from the water main to a customer's meter. SPU typically learns of water service failures through customer calls. SPU's service connection maintenance program is almost entirely reactive since it is generally not economical to perform preventative maintenance activities on water service lines. The consequences of failure on water service lines are low, and therefore it is more economical to run them to failure.

Meters. SPU's retail water meters ensure proper billing of its drinking water sales, as well as wastewater disposal costs. Billing system-generated meter problem reports may be generated under a variety of different conditions: broken meter dials; meters that have been inaccessible for reading for three attempts; consumption that is much higher or lower than what is expected for the customer based on historical information; meter registers that are stuck; and meters that show zero consumption. Customer-reported problems often arise from billing questions. When these problems arise, SPU works with each customer to quickly resolve the issues. Malfunctioning customer meters are much more likely to under-register than over-register.

A large meter outside the 97 to 103% accuracy range is either repaired to restore its performance or replaced. SPU does not typically repair small meters since it is generally cheaper to replace than repair them.

SPU maintains its distribution system water meters based on meter size and customer type. SPU has a meter testing and maintenance program for its large meters, which represent less than three percent of all retail meters. SPU's goal is to maintain accuracy of large meters to between 97 and 103 percent as per the guidelines of the American Water Works Association. A large meter with an accuracy falling outside that range is either repaired to restore its performance or replaced.

SPU does not typically perform maintenance activities for small meters since repairing small meters is not cost-effective and it is generally cheaper to replace a small meter than repair it. SPU replaces about 800 small meters each year.

Record Keeping and Reporting

SPU uses its MAXIMO work management system to capture asset failure, repair, and replacement history. Failure history is not completely reliable because many of the failure codes that were originally developed did not adequately describe the nature of the failure. This problem has since been resolved for all new data entered into the system.

SPU uses a geographic information system (GIS) to record and display locations of physical assets and problems. This tool is also utilized to review hydrant spacing and identify hydrants that have deficient spacing.

5.4 Needs, Gaps, and Issues

The primary needs, gaps, and issues facing SPU in the coming years are related to low pressures in isolated parts of the distribution system, aging distribution system infrastructure, seismic upgrades, and redevelopment. The following subsections summarize these concerns and SPU's approach to addressing them. SPU's process for resolving customer complaints is also described.

5.4.1 Pressure-Related System Deficiencies

Because of the range of elevations in SPU's water service area, SPU's distribution system is characterized by a wide range of service pressures. To evaluate low pressure areas, SPU uses its detailed hydraulic network models of its entire service area and performs comprehensive modeling of the entire distribution system.

Many of the low pressure situations can be attributed to the fact that portions of SPU's distribution system were designed to the 20-psi minimum service pressure standard in effect when they were originally installed. Other low pressure areas can be attributed to pressure losses due to degradation of pipelines or some combination of low pressure from reservoirs, tanks, or standpipes and pipeline degradation.

Several booster pump station projects have been proposed and built over the years to improve localized low pressure situations. The *2001 Water System Plan* identified the need for a new booster pump station at Phinney Ridge to correct low pressure. However, further analysis found that the area met the 20-psi minimum pressure standard, and it was not economical to construct the pump station to bring pressures above 30 psi.

The following improvements are planned to correct all known areas with service pressures below 20 psi and improve low (less than 30 psi) pressures in these areas where economical:

- Complete the Queen Anne Pump Station and Main Improvement Project currently in design. The booster pump station project for Queen Anne will benefit all domestic service connections and fire services inside the new zone, regardless of service size. The project will boost pressure for a significant number of services with marginal pressure within the defined new pressure zone to between 30 and 40 psi.

- Correct low pressure services that fall below the 20-psi minimum standard on Queen Anne Hill by expanding the Queen Anne 530 zone, creating a new sub-zone, or transferring the two impacted services to higher zones.

- Improve pressures in the Maple Leaf 530 zone north of the Maple Leaf Tank that are currently below 20 psi during peak hour design conditions. Preliminary engineering studies for these improvements are considering options for addressing the low pressure improvements together with the current Maple Leaf Tank seismic upgrade and painting projects.

5.4.2 Aging Infrastructure

Parts of Seattle’s water distribution system, in particular many of its pipelines, have been in place for more than a century. Although the existing system is in good condition, as evidenced by its low leakage rates, the system is continuing to age. In line with its asset management business model, SPU has developed a water main replacement program that provides a framework for making short-term pipeline rehabilitation and replacement decisions and projecting long-term pipe replacement and repair needs. The following sections describe the short-term and long-term aspects of the program and its impacts on future leakage rates and customer outages.

SPU's Approach to Water Main Replacement and Renewal

SPU has developed a distribution system renewal program that provides a high level of service to its customers while minimizing the life-cycle cost to the system. The life-cycle cost of an asset is the cost of owning, operating, maintaining, and disposing of that asset over its life. In general, replacement of a pipeline is economically justified when the cost of replacement is lower than the projected cost associated with repairing it. SPU's approach is based on industry-accepted best practices for infrastructure asset management that are widely used by water utilities in Australia, New Zealand, the United Kingdom, and more recently, by utilities in the US.

In general, replacement of a pipeline is economically justified when the cost of replacement is lower than the projected cost associated with repairing it.

SPU uses three tools, Waverider, a Pipe Replacement Model, and an Opportunity Model, to provide repeatable and supportable methods for making decisions about current and future capital and maintenance expenditures. In addition to these models, SPU has pipe rehabilitation programs to address water quality, pressure, and fire flow deficiencies.

Waverider Model. Waverider is a tool that SPU uses to project the long-term ownership costs of particular asset classes, such as pipelines. Replacement costs are projected by assuming that pipes will be replaced when they reach the end of their economic lives. The model considers the current age distribution of each pipe category to determine the length of pipe and cost in each year into the future. As shown in Figure 5-3, Waverider estimates an annual replacement cost of about $2 million for the near term for SPU's water pipes. That annual expenditure for replacement is projected to increase each year as pipelines age until it reaches $38 million in 2100.

The costs for repair of leaking pipes are projected to increase as each pipe category approaches the end of its economic life. Repair cost estimates in the years leading up to end of life are based on failure probability curves for each pipe category. The parameters defining these curves, and the economic life for each category, are adjusted yearly by SPU so that the current number of leaks and replacement cost in the model match the actual numbers. Figure 5-4 shows the current annual repair cost projection from Waverider is $1 million and peaks to about $16 million in 2097.

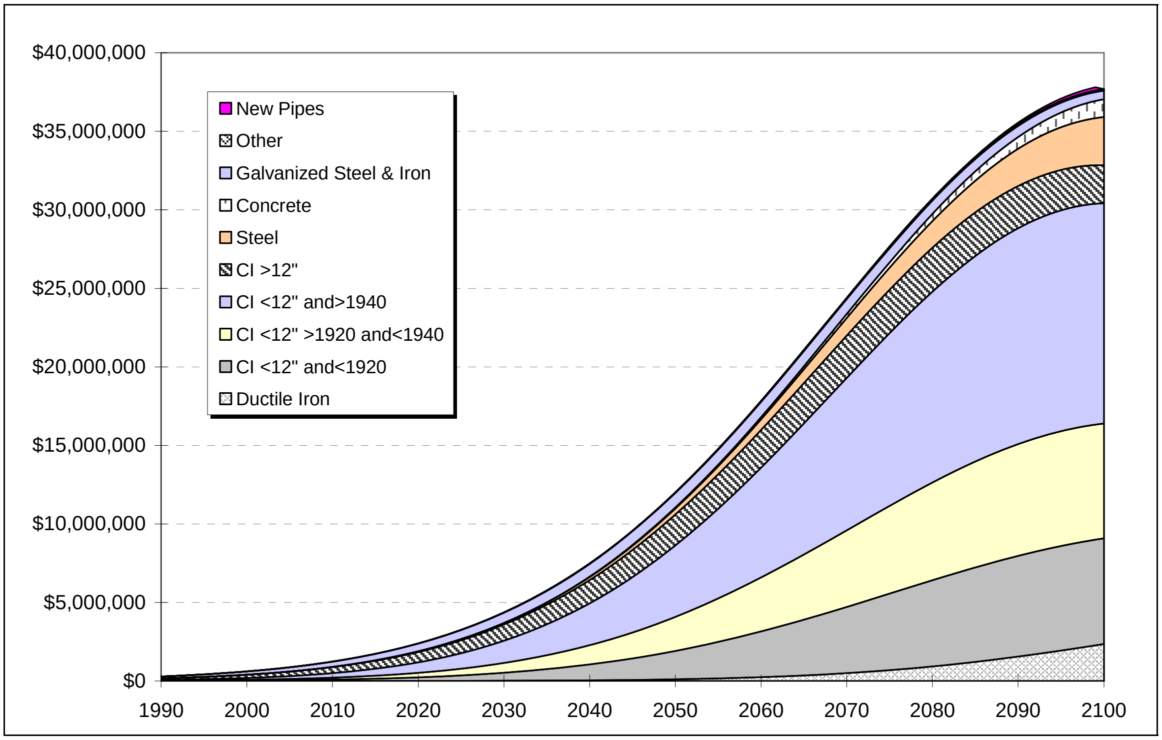


Figure 5-3. Long-Range Pipe Replacement Annual Cost Projection from Waverider for Different Types of Pipe

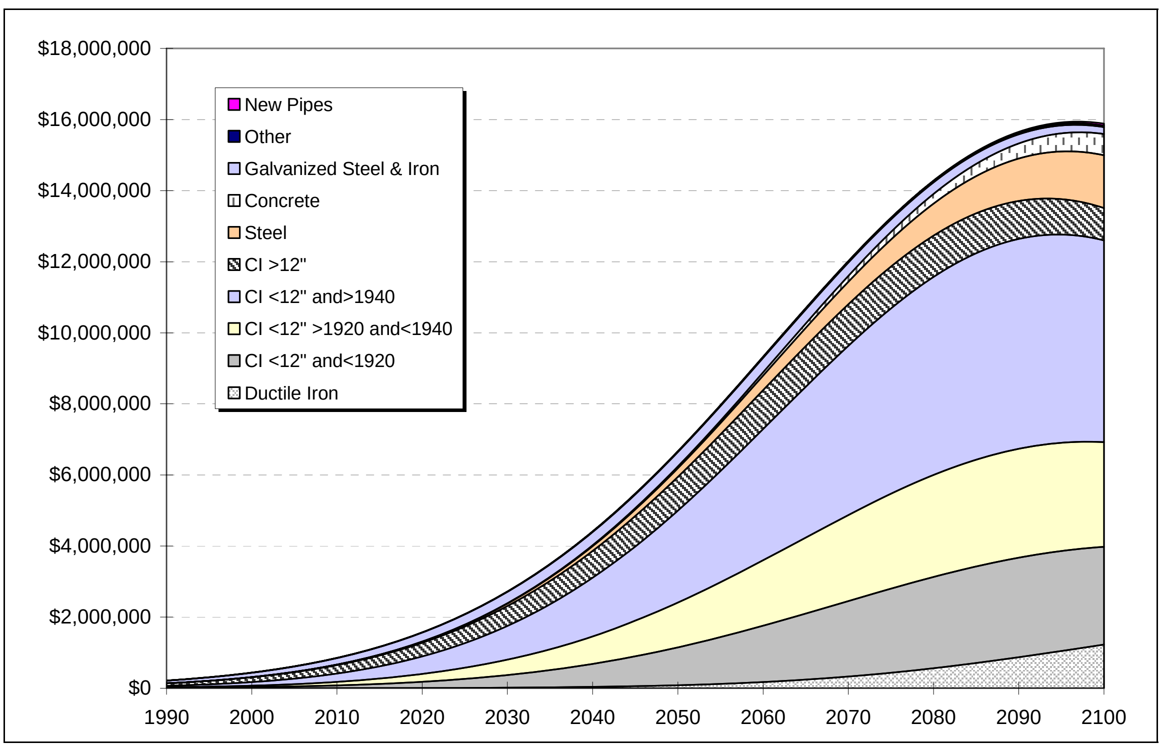


Figure 5-4. Long-Range Pipe Annual Repair Cost Projection from Waverider for Different Types of Pipe

Pipe Replacement Model. Whereas Waverider is a tool for projecting capital and O&M costs far into the future, the pipe replacement model is used to facilitate making decisions to replace specific pipe segments based on the benefit of avoided repair costs. Pipes with a series of recent failures are identified quarterly as pipe replacement candidates. The model compares the annualized cost of installing a new pipe to the marginal cost of repairs for the existing pipe to determine whether pipe replacement or continued repair is more cost-effective. In accordance with SPU's asset management framework, the costs analyzed include social and environmental costs, such as indirect cost for service outages, water loss, and traffic impacts. In recent years, the pipe replacement model has justified spending approximately $1 to 2 million per year on pipeline replacement.

Opportunity Model. In addition to relying on the pipe replacement model, SPU has numerous opportunities to reduce replacement costs by timing replacement with an upcoming capital project, such as a street pavement project. This coupling of projects reduces mobilization costs or street pavement restoration costs. This is advantageous if the cost saved is greater than the expected cost of replacing a pipe too early. SPU's opportunity model provides a tool to make these project timing decisions in a consistent manner.

Other Programs. SPU has other pipe rehabilitation programs to address water quality, seismic, and fire flow issues. SPU began implementing a pilot cleaning and lining program in 2005 for approximately 19,000 linear feet of unlined, cast iron pipe in the Ballard area. This project is expected to provide improved water quality, higher flow capacity, increased pressure, and added pipeline life while minimizing disruption to the community at a third of the cost of pipeline replacement. If the pilot is successful, SPU will re-line more of the 700 miles of unlined, cast iron pipe in the SPU system.

System Leakage

While SPU's Waverider and Pipe Replacement Model are useful in projecting long-term budget needs and deciding whether to repair or replace a particular pipe, costs are not the only concern for SPU. The water utility is also committed to meeting service levels described earlier in this chapter. One service level pertinent to aging pipes is system leakage. SPU's service level for leaks requires limiting distribution system leakage to less than 10 percent. SPU has examined its leakage history and projected its distribution system leakage well into the future in an effort to ensure that its replacement strategy meets the level of service.

Current Leakage. SPU's system leakage from pipes was estimated in the *2001 Water System Plan* to be up to 5.7 mgd. This value was based on quantification of SPU's non-revenue water. Recent system investigation has revealed that the 5.7-mgd estimate is probably high. Analysis of leakage using a methodology similar to that developed by the IWA for unavoidable real losses developed a range of estimates of the current leakage. Estimates of SPU's current system leakage losses from distribution and transmission pipelines, including service lines, using the IWA method, range between a low of 3.3 mgd and a high of 4.8 mgd, or between 5 and 7 percent of the 67 mgd produced in 2005 excluding that sold to wholesale customers.

Projected Leakage. To forecast future leakage rates, SPU used future projections of reported water main breaks from Waverider as well as assumptions regarding background leakage and unreported leaks and breaks for water mains and service lines. Table 5-2 summarizes the results of these calculations, showing the estimated leakage now and the projected leakage in 2095, when the system leakage is expected to peak, after which it begins to decline as the rate of pipe replacement increases. The table demonstrates that the low estimate of projected leakage from all sources, including the transmission system, does not exceed 10 percent of total retail demand, as per SPU's level of service. However, the middle and high leakage estimates project that the 10-percent limit could be reached in 2063 and 2048, respectively.

Table 5-2. Projected System Leakage

Method	Current Leakage	Projected in 2095	Exceeds 10% limit?
Low Estimate	3.3 mgd	9.1 mgd	No
Middle Estimate	4.1 mgd	12.4 mgd	Yes, in 2063
High Estimate	4.8 mgd	15.7 mgd	Yes, in 2048

Projected Outages

Water outages, where customers are without potable water for a period of time, can be caused by both planned and unplanned activities. Because outages are influenced by a utility's approach to water main repair and replacement, it is important to determine how the number and duration of outages will change in the future under SPU's planned replacement program.

Current Outages. The number of SPU retail services affected by outages longer than 4 hours per year (a typical threshold used in benchmarking surveys) is approximately 2,061 services, or 1.1 percent of customers based on 2002-2005 data.

Future Outages. SPU projected the future number of outages greater than 4 hours in duration per year from the projected number of water main failures and replacements from Waverider. The number of services affected per outage was then used to calculate the total number of services affected by outages in future years. It was assumed that outages caused by water main leaks and breaks and planned pipe replacements would increase according to the Waverider projections, while outages resulting from all other causes, such as new water main installations, relocations, broken service connections, and repairs/replacements of valves, would stay constant at the current levels.

Figure 5-5 shows the projected annual number of services affected by outages of greater than 4 hours for the next 100 years. The projections indicate that by 2052 approximately 7,200 customers would experience outages greater than 4 hours per year. This represents about 4 percent of SPU's retail customers, assuming the total number of service connections remains constant at about 180,000.

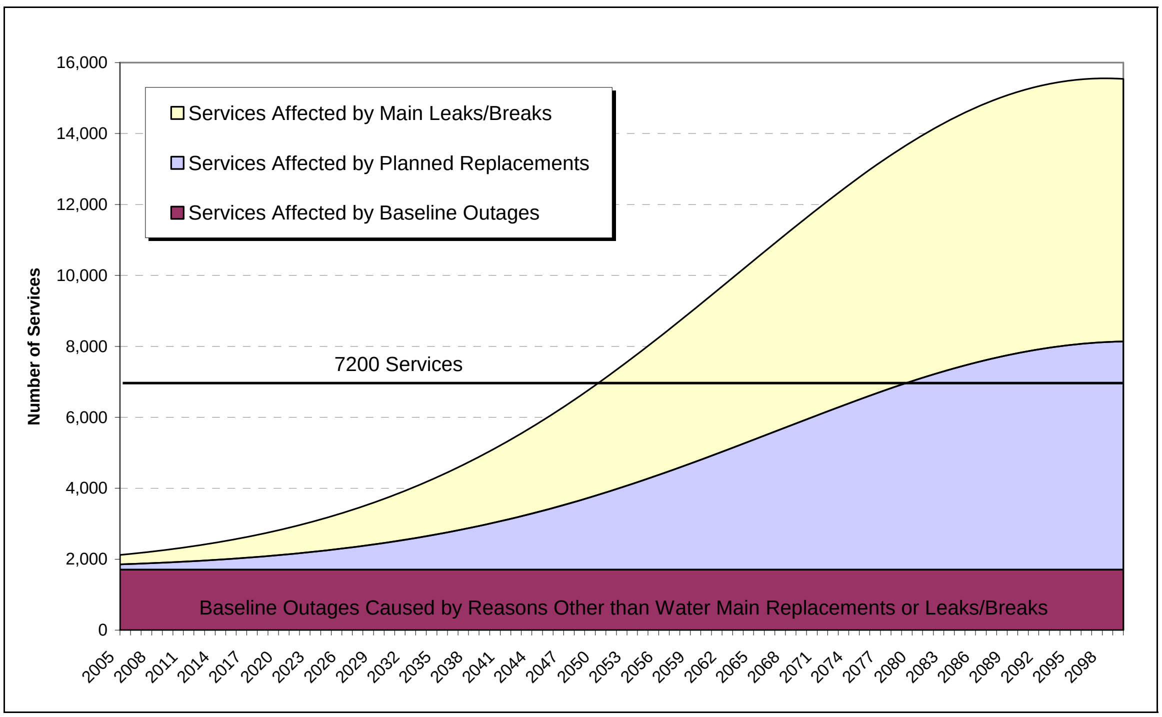


Figure 5-5. Projected Number of Services Affected by Outages Greater than 4 Hours per Year

SPU will be gathering data and refining the Waverider Model over the next 10 years to improve the projections and develop strategies for managing retail service outages.

Because leakage rates and the percentage of services affected by planned and unplanned outages is projected to remain relatively low for many decades, SPU has time to calibrate its assumptions, gather additional information, and assess needed changes. SPU is examining a variety of possible strategies to avoid excessive leakage rates and outages, including adding redundant valves or loops, using temporary lines, and throttling valves instead of shutting them completely while repairs are made. In addition, SPU will be gathering data and refining the Waverider Model over the next 10 years to improve projections and develop strategies for managing distribution system leakage and retail service outages.

5.4.3 System Redevelopment

Redevelopment activities can have a substantial impact on the ability of the existing distribution system to provide sufficient water to customers. Redevelopment typically increases the population density of an area and thereby increases the quantity of water that must flow through SPU's distribution system pipes. Often, extension of the distribution system or improvements to existing water mains in the redeveloped area becomes necessary to accommodate higher water demands and fire flows. Detailed hydraulic models are used in conjunction with area demand forecasts and fire flow requirements provided by the fire department to identify potential water main improvements in redevelopment areas.

New developments must meet the current fire code, and new hook-ups must be made to standard water mains. SPU reviews and provides a water availability certificate for each development as part of the City's permitting process. If there is a gap between what the existing system can provide and what the private development needs, the developer will be required to upgrade the existing system to meet requirements.

5.4.4 Backbone Pipeline System Seismic Upgrades

To mitigate the effects of earthquake pipeline damage on the water system functionality, SPU is implementing a program of backbone pipeline system seismic upgrades. As part of the program, the response of the entire water system to an earthquake that might be expected to occur once in 500 years was modeled to identify areas vulnerable to pipeline failures and water outages. The ground motions from such an earthquake would be similar to the 2001 Nisqually earthquake, except that the epicenter would be directly below Seattle instead of below Olympia, and the magnitude would be larger (7.5 vs. 6.8 for the Nisqually earthquake).

The findings of the hydraulic modeling indicate that large numbers of pipeline failures would likely occur in the Duwamish River Valley during such an earthquake, and would lead to immediate loss of water service in this and other seismically vulnerable areas. System damage and pipe breaks would cause most standpipes and elevated tanks south of the ship canal to drain within an hour or two. Beacon Reservoir would completely drain in approximately 8 hours. As the tanks and reservoirs drained, more and more areas, including Downtown, Capitol Hill, Queen Anne, the Rainier Valley, and West Seattle would lose water pressure.

The hydraulic modeling results show that, with the exception of a few areas, those areas north of the Ship Canal are much less likely to lose water service. The amount of expected damage north of the Ship Canal is expected to be low enough that the damaged areas could be isolated before Maple Leaf and Bitter Lake Reservoirs drained.

Replacing all the existing seismically vulnerable pipelines would cost over $3 billion. Replacing only the backbone pipelines considered essential for delivering drinking water and firefighting would cost approximately $1 billion. SPU has considered more cost-effective approaches to mitigating the seismic risks, including line valves to isolate the Duwamish River Valley area, and reservoir valves to maintain water in the in-ground reservoirs for drinking and firefighting. The exact location, operating strategy, hardware, and SCADA requirements for the line and reservoir valves are being evaluated.

The normal pipeline renewal process will involve replacing existing pipes with more seismic resistant pipe.

In addition to isolation strategies, the normal pipeline renewal process will involve replacing existing pipes with more seismic resistant pipe. As pipelines are replaced as part of the normal renewal process, the pipeline system will gradually become more resistant to seismic events.

5.4.5 Customer Complaint Response

SPU has developed procedures for responding to complaints and problems reported by its retail customers. The vast majority of complaints concern water quality problems, in particular muddy or brown water. Few complaints are made about pressure, and these are almost always found to be on-property service line problems. Figure 5-6 shows the breakdown of water quality complaints in 2005.

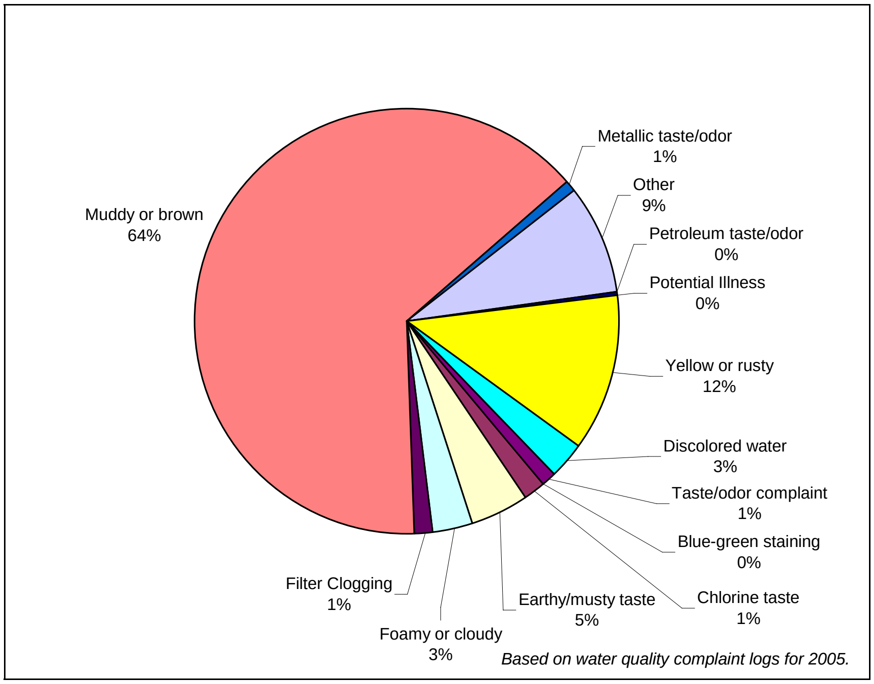


Figure 5-6. Types of Water Quality Complaints in 2005

SPU retail customers with water quality concerns, water service problems, or questions contact the SPU Call Center during normal business hours and SPU's dispatcher after hours and on the weekends. Calls that involve water quality concerns or identify high priority problems–calls that concern public health issues or safety risks–are immediately forwarded to an inspector who will investigate the problem until it is resolved.

The current procedures, which were implemented in 2003, have several advantages over SPU's former complaint response process, which consisted of customers leaving a voice mail message to which SPU would respond sometime later. The new process puts the customer in immediate contact with SPU staff and provides SPU with up-to-date knowledge of from where the complaints are coming, the nature of the complaints or problems, and how many are being received from a given area of Seattle. SPU is also able to better track the customer calls from the service orders that are created and logged into its computer system. Specific information on individual customers is kept with Customer Service records for a period of five years.

SPU is able to better track the customer calls from the service orders created.

The Laboratory Services Division also maintains records of water quality monitoring related to customer complaints. Records kept on file at the Water Quality Lab for a minimum of five years include any bacteriological and chemistry analyses that are performed.

5.5 Implementation/Action Plan

As described in this chapter, the major issues facing the distribution system include areas with low pressure, appropriate investments for aging infrastructure, upgrading water mains in redevelopment areas, potential damage resulting from a major seismic event, and managing the system to meet service level targets. SPU has identified the following actions to address these issues:

- Improve pressure to areas where services have less than 20 psi on Queen Anne Hill, in the lower Queen Anne 326 pressure zone, and in the Maple Leaf 530 pressure zone.
- Renew or replace aging water mains using the policies and procedures described in this chapter.
- Collect SPU-specific failure data to refine the Waverider Model.
- Continue working with developers where water main replacements or upgrades in redevelopment areas are required to meet current fire flow code requirements and water main standards to make sure that the developers cover upgrade costs.
- Replace backbone pipelines essential for delivering drinking water and firefighting to minimize loss of service following an earthquake. Other approaches to mitigating the seismic risks include line valves and reservoir valves.
- Manage retail service provision, problem response and leakage to meet service level targets.

PART II: PLAN IMPLEMENTATION

Part I of the *2007 Water System Plan* presents SPU's water system business "roadmap" for the next six years and beyond. The first chapter of Part II details the anticipated costs of implementing that roadmap through 2030, with a particular focus on the next six years. The second chapter of Part II presents SPU's plan for financing identified operations and capital facilities improvements and priorities in addition to supporting the existing and ongoing costs of SPU's water utility operations.

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Chapter 1
Budget

Seattle City Council

Part I identified a number of needs, gaps, and issues facing SPU in each of its business areas. This chapter focuses on the budget required to implement capital programs and operations and maintenance (O&M) activities to meet SPU's regulatory and customer service objectives, including addressing the needs and gaps identified in Part I of this plan. The first part of the chapter begins by describing SPU's process for developing a capital improvement budget for the water system. Later, the chapter identifies a draft budget for the six-year capital improvement plan (CIP) and 25-year capital facilities plan (CFP) and O&M budget outlook for the water line of business.

1.1 CAPITAL IMPROVEMENT BUDGETING

SPU has made a major commitment to using an asset management approach in selecting which capital improvement projects go forward.

Since the *2001 Water System Plan* was prepared, SPU has made a major commitment to using an asset management approach in selecting which capital improvement projects go forward. Asset management is a method of meeting established and well-defined service levels at a cost that represents the highest life cycle value to the utility and its ratepayers. This may lead to new capital projects or shifts in O&M activities. By adopting an asset management approach, SPU is better able to ensure cost effectiveness in service delivery in the long-run. Key elements of SPU's asset management approach are described below.

1.1.1 Project Development Plan

As described in Part I, evaluation of a proposed capital improvement project for funding begins with preparation of a project development plan (PDP) prepared by the sponsoring business area. The PDP identifies the project's objectives and describes a business and technical strategy for achieving those objectives. Several options for achieving objectives are identified, and then the PDP summarizes the business case for the project, including an analysis of alternative solutions and the net present value of the proposed projects and preferred solution.

1.1.2 Benefit-Cost Analysis

For a capital improvement project to be funded, the PDP for the project must demonstrate that it will provide a positive net present value to SPU and its ratepayers. An improvement's net present value is calculated by identifying all its costs and benefits and, to the extent possible, quantifying them in dollar terms. An appropriate discount rate is used to convert future costs and benefits to equivalent present values. The net present value of a project is the present value of the benefits minus the present value of the costs. Projects which fail to show a positive net present value would not be funded, and in selecting from a number of options to achieve a project's objectives, the one that produces the highest net present value would normally be the option that is preferred.

Alternatively, if a project is required to meet a service level or regulatory requirement, a cost-effectiveness analysis is performed. For these types of projects, the benefits or the value added are equivalent, and the option with the lowest life-cycle costs is preferred.

Life-Cycle Cost Analysis

Life-cycle cost analysis is a process whereby all the capital, operating, social, environmental, and risk costs of a project are analyzed over the expected life of the asset. Costs include the capital cost of acquiring or constructing the improvement or asset, as well as the cost of operating and maintaining the asset over its life cycle.

Triple-Bottom-Line Analysis

Triple-bottom-line analysis takes into account financial, social and environmental costs and benefits.

SPU does not limit its evaluation of projects to just the direct financial aspects. An approach known as triple-bottom-line analyses is applied to assess all of the known and reasonably anticipated economic, environmental, and social impacts of a project (not just those that can be quantified in dollar terms) from a variety of perspectives. SPU has developed a *Triple Bottom Line Guidebook* to standardize this analytical approach and provide techniques for determining values for the social and environmental costs and benefits that are often difficult to quantify in dollar terms. The value modeling used in the Water Supply Planning Model (described in Part I) is an example of a method used by SPU to evaluate costs and benefits that cannot be put into dollar terms.

Risk Costs

The presence of risk can make benefit/cost analysis more complicated. Risk cost is a special cost category that quantifies exposure to uncertain or probabilistic costs, such as those which could potentially arise from the failure of an asset. Risk is calculated as the product of the probability of the risk event times the consequence cost of the event. Risk cost is expressed as an annual cost by using the annual probability multiplied by consequence. It can then be handled like other project costs in the benefit-cost analysis.

1.1.3 Asset Management Committee Review

Projects or programs that are projected to cost $250,000 or more over their life, considering both capital and O&M costs, must be reviewed by SPU's Asset Management Committee (AMC), which is composed of SPU's Executive Team. Water CIP projects that are estimated to cost less than $250,000 must be reviewed by the AMC for the water line of business.

1.2 BUSINESS AREA ACTIONS AND COSTS

Part I of this *2007 Water System Plan* identifies key actions for each water utility business area over the next six years. Those key actions related to capital projects are recapped below for each business area. An overview of the draft 2007-2012 CIP budget (April 2006), summarized according to business areas, is presented in Table 1-1. The detailed draft CIP is provided as an appendix. CIP cost estimates presented in this plan are preliminary and subject to change as the projects are further developed and analyzed. CIP projects are subject to AMC approval and budget adoption by the Seattle City Council.

Table 1-1. Capital Improvement Program Budget 2007-2012 (April 2006 Draft in thousands of 2006 dollars)

Business Area	2007	2008	2009	2010	2011	2012	Total
Water Resources	9,600	8,400	15,900	18,300	4,600	1,500	58,300
Water Quality and Treatment	26,100	16,300	16,800	6,500	17,800	30,700	114,200
Transmission	3,500	2,500	2,500	2,800	3,500	3,300	18,100
Distribution	29,700	20,600	20,700	20,600	20,600	20,900	133,100
Other	38,900	28,800	20,100	24,900	20,900	12,400	146,000
Total	107,800	76,600	76,000	73,100	67,400	68,800	469,700

1.2.1 Water Resources

Major CIP projects for the Water Resources business area include the following:

- Implement both regional and local water conservation programs such as the 1% Program and the City of Seattle I-63 SO, and measures to achieve the 2011-2030 Regional Conservation Program goals. SPU expects to spend in the range of $1.3 million annually on regional conservation programs, with approximately $550,000 from the capital improvement budget and $750,000 from operation and maintenance funds, assuming that SPU pays 50 percent of the cost of hardware measures to provide incentives for customers.

- Complete remedial work and monitoring improvements to address Cedar moraine safety issues, as appropriate. The draft CIP includes an estimate of $775,000 in 2007-2008 for this work.

- Design and construct flood passage improvements at Landsburg Diversion Dam on the Cedar River. The improvements include replacement of two existing spillway gates with one larger, radial gate and installation of a trash rake system for debris handling. The CIP includes a cost estimate of $2.6 million to complete this work in 2007-2009.

- Evaluate and implement preferred option for delivering water from Chester Morse Lake dead storage during drought emergencies. Options analyzed include modifications to the existing system, construction of a new pump station and discharge pipelines, and tunnel options. Various options for stabilizing the outlet channel are also being evaluated. Assuming construction of a new pump station is selected as the preferred alternative, this project is estimated to cost $27,210,000 and will take approximately five years to complete (2007-2011).

1.2.2 Water Quality and Treatment

Continued implementation of the open reservoir covering/burying program comprises the bulk of the CIP projects in the Water Quality and Treatment business area:

- The Myrtle Reservoir Replacement Project is projected to be substantially complete in 2007 and has a total remaining cost of approximately $7 million.

- The Beacon Reservoir Replacement Project is projected to be substantially complete in 2008 and has a total remaining cost of approximately $29 million.

- The West Seattle Reservoir Replacement Project is estimated to cost $28 million with substantial completion projected for 2010.

- The Maple Leaf Reservoir Replacement Project is estimated to cost $47 million with a projected substantial completion date of 2013.

- Volunteer Reservoir Replacement Project is scheduled for 2015, which is not within the six-year CIP. However, preliminary engineering work for this project is scheduled for 2010 through 2012 and is estimated to cost $1.6 million. Total cost of the project, assuming replacement, is estimated to be almost $19 million. This reservoir may be decommissioned, but additional analysis is required to confirm this action.

- Roosevelt Reservoir is scheduled for decommissioning in 2015 and is not included in the six-year CIP.

1.2.3 Transmission

The major CIP projects identified for the transmission system include the following:

- Implement cathodic protection for transmission pipelines. This is estimated to cost $0.5 million per year in 2007-2012.

- Cover the Control Works surge tanks. This project is estimated to cost $600,000 and is included in the CIP for 2007-2008.

- Complete the Cedar/Tolt optimization study and implement improvements to allow greater flexibility in using water from each source. Projects include completion of Maple Leaf gatehouse piping with a cost estimate of $280,000, and other improvements yet to be identified.

- Recoat and upgrade Myrtle, Richmond Highlands and Beverly Park tanks. The total cost for this work is estimated to be $5.5 million.

1.2.4 Distribution

Several ongoing improvement programs for the distribution system are contained in the CIP. These and other major CIP projects identified for the distribution system include the following:

- Complete Queen Anne Booster Pump Station and Standpipe Replacement Projects. This is estimated to cost $10 million.
- Implement Backbone Pipeline System Seismic Upgrades. Almost $3 million is included in the draft six-year CIP to cover the estimate cost of these upgrades.
- Reline or replace aging water mains and improve pressures and fire flows where cost-effective. The draft six-year CIP includes more than $5.5 million per year for this work.
- Extend water mains to new developments. The draft six-year CIP includes approximately $1 million per year for this work.
- Relocate water mains impacted by other projects (large and small) and upgrade water mains in redevelopment areas. This work includes water system improvements and enhancements required for major projects by other agencies, such as the Alaskan Way Viaduct and seawall. The draft six-year CIP includes more that $18 million for these types of projects.
- Replace leaking service connections and install new services. The draft six-year CIP includes approximately $10 million per year for this ongoing work.
- Replace meters. The draft six-year CIP includes more than $600,000 per year for this ongoing work.

1.2.5 Other Water Utility Capital Projects

In addition to the major projects discussed in this water system plan and summarized above, SPU has identified a number of other water system capital projects to be implemented over the next six years. These projects include those in the Major Watersheds business area, such as roads and bridge improvements in the watersheds. Projects involving more than one business area yet important for achieving the overall goals of the drinking water utility are also included here. These other projects and their costs are listed in Table 1-2.

Table 1-2. Other Capital Projects and Six-Year CIP Costs (April 2006 Draft in thousands of 2006 dollars)

Capital Improvement Program Projects	2007	2008	2009	2010	2011	2012	Total
Major Watersheds	20,000	14,200	4,900	4,900	3,400	3,000	50,400
Regional Facility Improvements	2,000	2,100	3,300	2,800	1,700	1,200	13,100
Seattle Facility Improvements	1,700	1,700	2,400	800	400	300	7,300
Tank/Standpipe Site Remediation	200	200	10	30	0	0	440
Water Design Standards	300	300	0	0	0	0	600
Heavy Equipment Purchase	3,300	1,500	1,500	4,200	4,000	1,000	15,500
SCADA System	4,100	1,600	1,100	5,300	4,500	25	16,625
System-Wide Security Improvements	1,900	1,00	1,200	1,200	1,200	1,200	8,100
Information Technology	5,600	5,800	5,700	5,700	5,700	5,700	34,200
Total	39,100	28,800	20,110	24,930	20,900	12,425	146,265

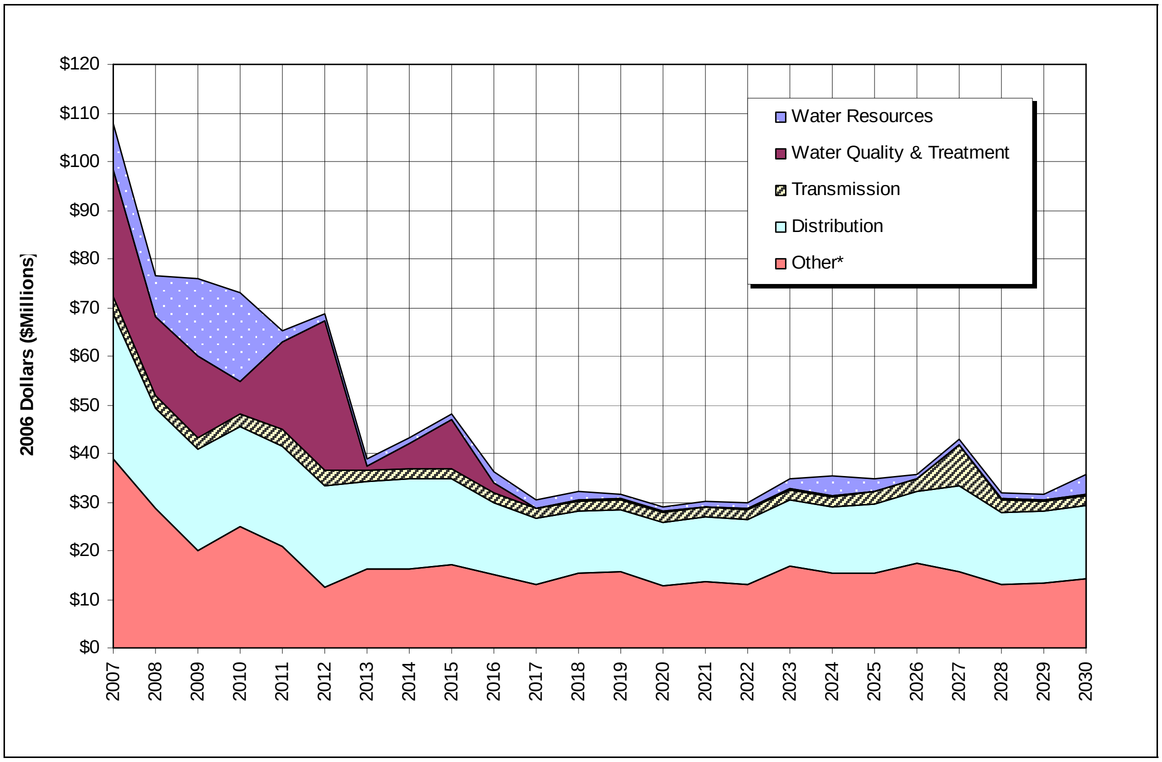
1.3. LONG-RANGE CAPITAL FACILITIES PLAN BUDGET

In addition to developing the six-year capital improvement program summarized above, SPU has developed its best estimate of a Capital Facilities Plan (CFP) budget through 2030, given what is known and anticipated at this time. Beyond 2012, the range of uncertainty in project costs and timing is greater. While projections are shown through 2030, experience has shown that new requirements emerge and projections change over time. The CFP budget estimate is provided as an appendix and summarized in Table 1-3. SPU's proposed CFP totals to more than $1 billion for 2007-2030. Approximately one-third of this is to replace aging infrastructure that is anticipated to reach the end of its useful life.

Figure 1-1 graphically represents SPU's long-range CFP budget for the water utility. Capital spending is expected to be highest in the earlier years, primarily due to completion of the reservoir burying program (Water Quality and Treatment) and Chester Morse Lake Dead Storage Facilities Project (Water Resources). Increased expenditures in 2027 are expected due to the recovering of Bitter Lake and Lake Forest Park Reservoirs (Transmission).

Table 1-3. Capital Facilities Plan Budget through 2030 (April 2006 Draft in thousands of 2006 dollars)

Business Area	2007-2010	2011-2015	2016-2020	2021-2025	2026-2030	Total
Water Resources	52,100	9,800	8,000	10,700	8,600	89,200
Water Quality and Treatment	65,700	64,600	2,800	750	750	134,600
Transmission	11,300	13,200	10,100	10,600	17,600	62,800
Distribution	91,600	95,600	67,100	68,400	77,100	399,800
Other	112,600	83,100	71,900	74,300	73,700	415,600
Total	333,300	266,300	159,900	164,750	177,750	1,102,000



* Note: Includes Major Watersheds, Fleets, Facilities, Security, Information Technology, SCADA, Water Design Standards, and other miscellaneous projects.

Figure 1-1. Proposed Capital Facilities Plan Spending through 2030 (2007-2012 CIP estimate from 4/7/06)

SPU's *2001 Water System Plan* included a long-range capital facilities plan for the water utility. That plan covered the period 2001 through 2020. Table 1-4 compares the CFP budget for the 2001 plan with the CFP budget presented in Table 1-3 and Figure 1-1.

As Table 1-4 shows, SPU has increased its capital spending projections since its *2001 Water Systems Plan Update* primarily due to changes in the reservoir burying program, security investments, and proposed improvement to the Chester Morse Lake dead storage facilities.

Table 1-4. Comparison of Capital Facilities Plan Budget Estimates from *2001* and *2007 Water System Plans* (in millions of dollars)

Water System Plan	2007-2010	2011-2015	2016-2020	2021-2025	2026-2030
2001	194	185	174	N/A	N/A
2007	333	264	160	165	178
Increase/(decrease)	139	79	(14)	N/A	N/A

1.4 O&M Budget Outlook

Water system operating expenses through 2030 are expected to grow slightly faster than the rate of inflation. The most significant increase in projected O&M expenditures is due to anticipated water main repair costs. These costs are necessary to maintain pipes as the distribution system continues to age. All other changes to O&M expenditures are assumed to balance out; anticipated future efficiency gains in O&M practices and methods are assumed to roughly equal other O&M cost increases. After increasing from $60 to $62.5 million in 2007, annual O&M costs are expected to increase very gradually to $65.2 million in 2030 (2006 dollars). This is a total increase of 4.3 percent over the 24-year period in real terms. The O&M cost outlook is shown in Figure 1-2.

In contrast to the *2001 Water System Plan*, increases in O&M costs for the treatment plants are now included in the base. In addition, O&M costs related to the Tacoma Second Supply Project have been removed since SPU is no longer participating in that project.

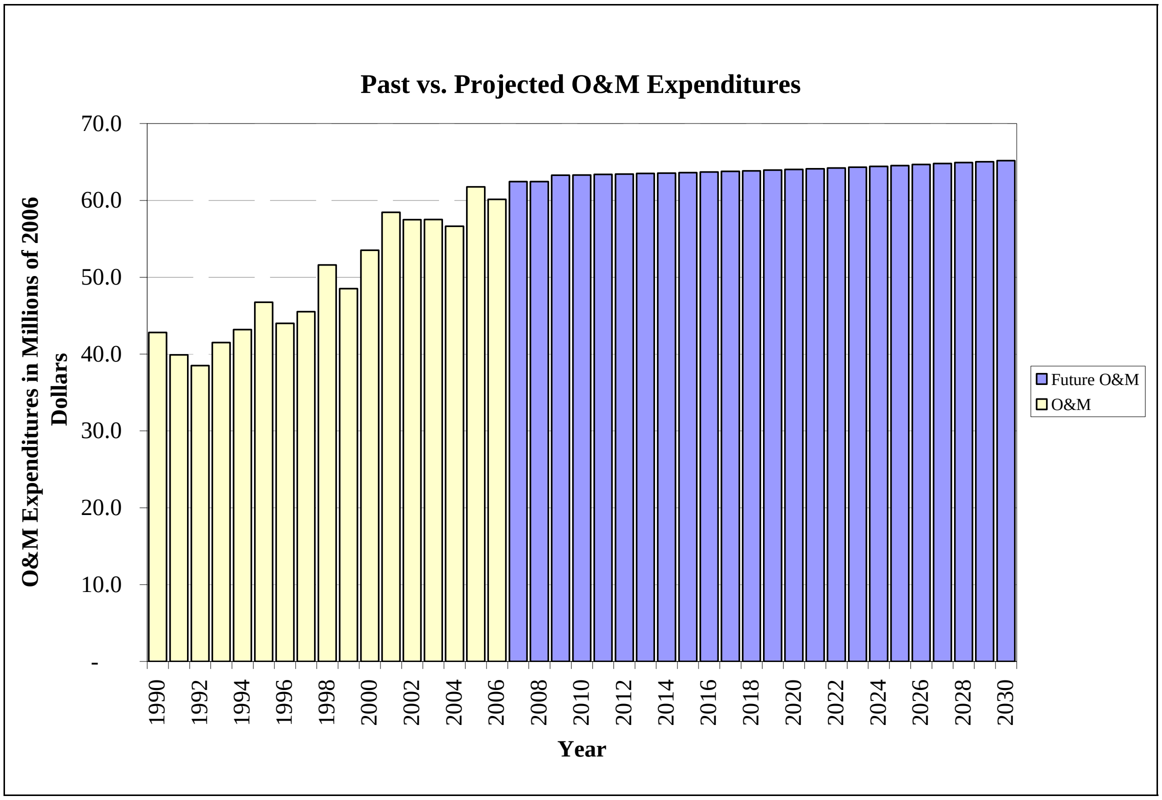


Figure 1-2. 30-Year O&M Budget Outlook

Chapter 2
Financial Program

***Our Water.
Our Future.***

This chapter describes the likely methods of financing the estimated cost of operating SPU's water system and investing in the capital projects described in Chapter 1 of Part II.

2.1 FINANCIAL POLICIES

Financial management of the water system is directed by formal financial policies adopted by the City Council and by informal guidelines that have evolved over time in response to specific issues. These policies and guidelines are used to decide how to finance water system operations and capital projects. They are intended to ensure that the water system finances its costs in such a manner that specific policy goals are achieved. These goals are:

- To ensure the financial integrity of the water utility.
- To moderate rate increases for water system customers over the near and medium term.
- To ensure an equitable allocation of capital costs between current and future ratepayers.

In 2005, the City Council adopted new water system financial policies that reflect changes and additions to the financial policies adopted in 1992. The new financial policies are more appropriate for the current financial environment and capital financing requirements, and also reflect changes made in 2005 to the conditions for activity in the Revenue Stabilization Subfund. The financial policies are as follows:

1. Maintenance of Capital Assets. For the benefit of both current and future ratepayers, the municipal water system will seek to maintain its assets in sound working condition. Future revenue requirement analyses will include provision for maintenance and rehabilitation of facilities at a level intended to minimize total cost while continuing to provide reliable, high quality service.

2. Debt Service Coverage. Debt service coverage on first-lien debt should be at least 1.7 times debt service cost in each year on a planning basis.

3. Net Income. Net income should generally be positive.

4. Cash Funding of the Capital Improvement Program. Current revenues should be used to finance no less than 15 percent of the municipal water system's adopted CIP in any year, and not less than 20 percent of the CIP over the period of each rate proposal. Cash in excess of working capital requirements may be used to help fund the CIP.

5. Eligibility for Debt Financing. Unless otherwise authorized by the City Council, the following criteria must be met before project expenditures are eligible for debt financing:

    - Project is included in the CIP.
    - Total project cost exceeds $50,000.
    - Project has expected useful life of more than two years (more than five years for information technology projects).
    - Resulting asset will be owned or controlled by SPU, is part of the regional utility infrastructure, or represents a long-term investment for water conservation.
    - Consistent with generally accepted accounting practices, project costs include those indirect costs, such as administrative overhead and program management, than can be reasonably attributed to the individual CIP project.

Revenue Stabilization Subfund is available to offset shortfalls in metered water sales revenues or to meet financial policies.

6. Revenue Stabilization Subfund. A target balance of $9 million will be maintained in the Revenue Stabilization Subfund, except when withdrawals below this level are needed to offset shortfalls in metered water sales revenues or to meet financial policy requirements. Funds in excess of the minimum balance may be used to meet operating expenses, pay CIP expenditures, or meet financial policy requirements.

    SPU may also make discretionary deposits to the Revenue Stabilization Subfund, provided that these discretionary deposits are in excess of the amounts required to meet the financial policy requirements. Should the balance in Subfund fall below the target balance, within one year SPU shall submit a water rate proposal that rebuilds the balance in the Subfund.

7. Cash Target. The target for the year-end operating fund cash balance is one-twelfth of the current year's operating expenditures.

8. Variable Rate Debt. Variable rate debt should not exceed 15 percent of total outstanding debt. Annual principal payments shall be made on variable rate debt in a manner consistent with fixed rate debt.

The financial policies help determine how much revenue the utility must collect from its customers each year to meet the cost of operations, maintenance and repair, and capital improvements. Because of this, rate impacts stemming from specific courses of action recommended in this water system plan cannot be determined without also considering what financial policies are to be followed. If an action's rate impacts are unacceptable, the action can be scaled back to reduce costs or alternative financial approaches can be considered to spread costs over a longer period.

2.2 Financial Health

Financially healthy organizations have the flexibility to respond to unexpected circumstances. Such circumstances may include new, unexpected-but-essential tasks or a shortfall in earnings. Flexibility can mean redirecting expenditures, borrowing money to meet an unexpected need, or other approaches.

The use of debt to finance a significant amount of new and replacement infrastructure has kept rates low but increased the amount of revenue used to repay loans.

In the past, the water system financed a significant amount of new and replacement infrastructure through the use of debt. While it helped keep rates low at that time, it has also greatly increased the portion of revenue that is used to pay off the debt. In 1990, 20 cents of every revenue dollar was used to repay loans. In 2006, 40 cents of every revenue dollar was used to repay loans. This means that SPU has less flexibility in how it spends its revenues. Current revenues that are used for new facilities are the most flexible resource for meeting unexpected needs.

The increasing commitment of each revenue dollar to pay off debt makes sources of financial instability more risky because SPU has less flexibility to adjust to revenue shortfalls and unexpected needs. One cause of revenue fluctuation for SPU is seasonal rates, which are used to discourage water use in the summer when water is most scarce. Variations in summer weather can cause annual water use to vary from an average year by 2 to 3 percent. Since this variation happens in the summer, when rates are higher than the winter, summer weather variation can result in revenue shortfalls of 3 to 4 percent. The Revenue Stabilization Subfund can be used to offset revenue shortfalls beyond these levels.

Reducing this weather-related revenue risk could also be accomplished by reducing the difference between winter and summer rates. Higher rates would provide more annual revenue and therefore more of a “cushion” against revenue shortfalls. However, changing the seasonal rate structure would reduce incentives to conserve water in the summertime.

There are two key indicators used to gauge SPU’s financial performance: debt-service coverage and debt-to-assets ratio.

There are two key indicators used by the financial community that provide a measure of how well SPU is doing in the areas identified above. The first, debt-service coverage, is an annual measure of the revenue an organization has available to repay debt, divided by debt payments. Debt-service coverage is calculated after operations expenses and some taxes have been paid. SPU’s debt-service coverage policy target is 1.70. SPU is expected to meet this target in the period covered by this plan.

The second key indicator is the debt-to-assets ratio. The debt-to-assets ratio is the outstanding debt of the organization divided by the sum total of its assets. The debt-to-assets ratio shows how reliant the organization is on debt to finance its infrastructure and how much flexibility is has to respond to unexpected circumstances. SPU’s debt-to-assets ratio is currently higher than comparable utilities and is at a level that could be a concern to the financial community, which could result in higher debt financing costs if investors view SPU as overextended. In recent years, however, SPU has had excellent bond ratings.

SPU has been decreasing the levels of debt financing of its capital improvement program over the past few years and is expected to continue to do so. This increase in revenue financing of a very large capital program, combined with higher debt service, will drive significant rate increases in the near future. However, by investing more current revenue in infrastructure, SPU will reduce its reliance on debt and thereby reduce its debt-to-assets ratio.

A summary of SPU’s financial results for its water utility over the past six years is shown in Table 2-1.

2.3 FUNDING SOURCES

The primary source of funding for SPU’s water utility are revenues derived from the wholesale and retail sales of treated drinking water.

The primary source of funding for SPU’s water utility are revenues derived from the wholesale and retail sales of treated drinking water. To finance capital facilities, SPU relies primarily on borrowing. SPU also receives contributions from developers, but that funding source plays a much smaller role in capital financing. The water system is in a period of unprecedented growth in capital expenditures. From 2007 through 2030, SPU plans to meet or

Table 2-1. Financial Revenues and Expenditures, 2000–2005 (in millions of dollars)

	2000	2001	2002	2003	2004	2005
Revenues						
Water Sales	104	104	115	133	140	136
Other (tap fees, interest income, operational grants, reimbursements, etc.)	9	5	4	5	5	11
Total	112	109	119	138	144	147
Expenditures						
Operations and Maintenance	44	52	52	54	54	60
Taxes	11	11	12	14	15	20
Debt Service	44	47	49	51	55	59
Revenue-Financed Construction	5	3	5	13	11	4
Total	104	112	119	132	134	144
Net of Revenues and Expenditures:	8	-3	0	6	10	3

exceed its financial policy of financing 20 percent of its capital facilities plan with revenues. However, because of the large size of the CIP in the next six years, SPU will still rely heavily on borrowing. This will result in larger rate increases in the near term but will increase future flexibility to respond to unexpected events and will help maintain or improve current bond ratings.

2.3.1 Water Rates

In 2005, water sales made up 96 percent of operating revenues.

In 2005, water sales made up 96 percent of operating revenues. Rates must provide sufficient revenue to operate the water system. Rate-setting objectives include:

- Provide financial soundness.
- Advance economic efficiency.
- Promote customer equity.
- Encourage customer conservation.
- Contribute to transparency and customer understanding.
- Reduce impacts on low-income customers.

The affordability of rates to retail customers is also an issue considered by City Council during rate setting.

Rates are set by customer class. The major customer groupings are wholesale and retail. Wholesale rates are set as described in their contracts with SPU. Retail customers are further categorized into residential and commercial classes. The rate structure for each of the customer classes includes a fixed monthly charge, which is graduated by the size of the service, and a seasonally-differentiated commodity charge. The combination of fixed and commodity charges can be fine tuned to meet the rate objectives identified above. For example, the fixed charge can be set to recover costs that are unrelated to the amount of water used, such as billing and meter reading. Similarly, seasonal commodity rates can be set to reflect the cost differentials that exist between winter, when stream flows are high and demand is low, and summer, when stream flows are low and demand is high. Setting rates so that the bills of individual customers reflect the cost of serving them is especially important in achieving customer equity because the most commonly used definition of equity is that bills reflect costs.

To encourage conservation in the summer period, the residential commodity rate is structured with three tiers. The first tier (up to 500 cubic feet (CCF) is designed as a “lifeline” to meet basic needs. The second tier (from 5 to 18 CCF) is billed at a higher rate than the first. The third tier (above 18 CCF), instituted in 2001 in response to a citizens’ initiative for water conservation (I-63 SO, described in Part I), is set at an even higher rate to discourage the use of very large volumes of water, often for irrigation.

System-wide rates have increased and will continue to increase faster than the rate of inflation. A significant portion of the rate increases are due to debt service on prior capital investments, such as the Tolt and Cedar Treatment Facilities. The large CIP for the next six years is also another significant contributing factor. The system-wide average rate is expected to increase from $2.30 per CCF of water in 2007 to a peak of $2.49 per CCF in 2015 (2006 dollars). This rate path, and the costs that drive the total rate, are shown in Figure 2-1.

As mentioned previously, a large driver of rates in the near term is the debt service associated with investments in the water system that have already been made. Without recent improvements to the system, rates would be comparable to those that existed after the original construction period, as shown in Figure 2-2.

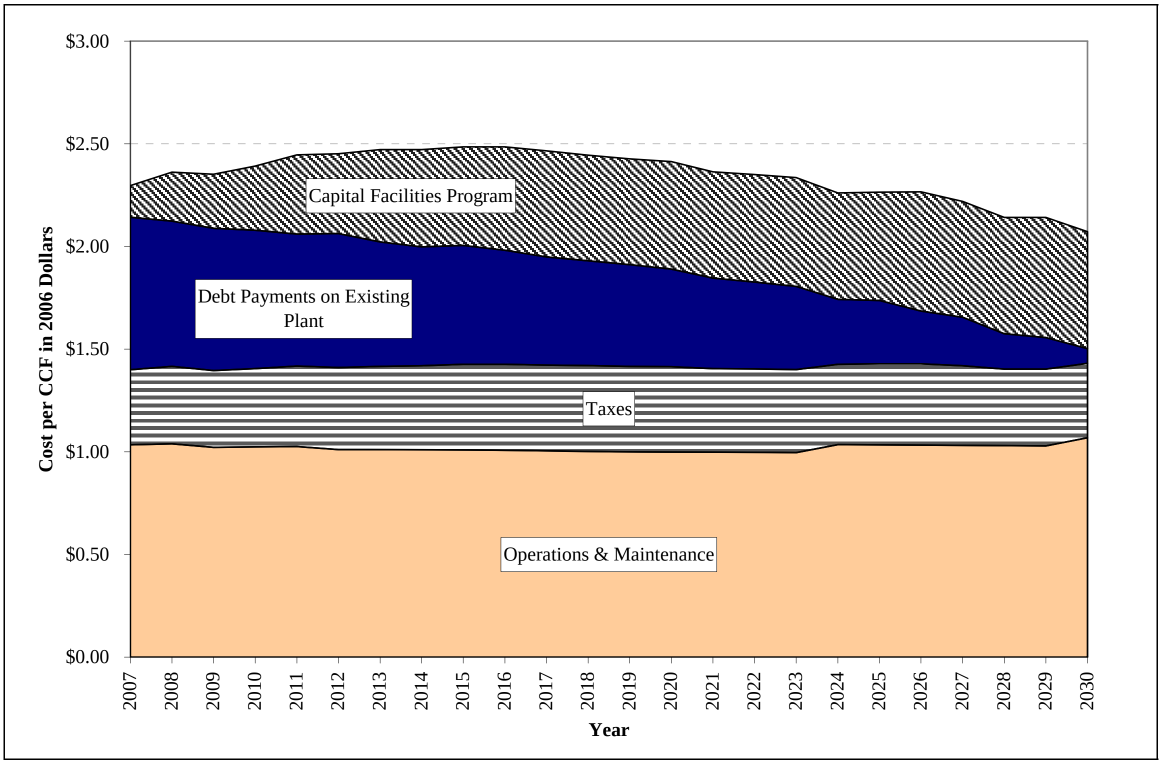


Figure 2-1. Rate Component Costs

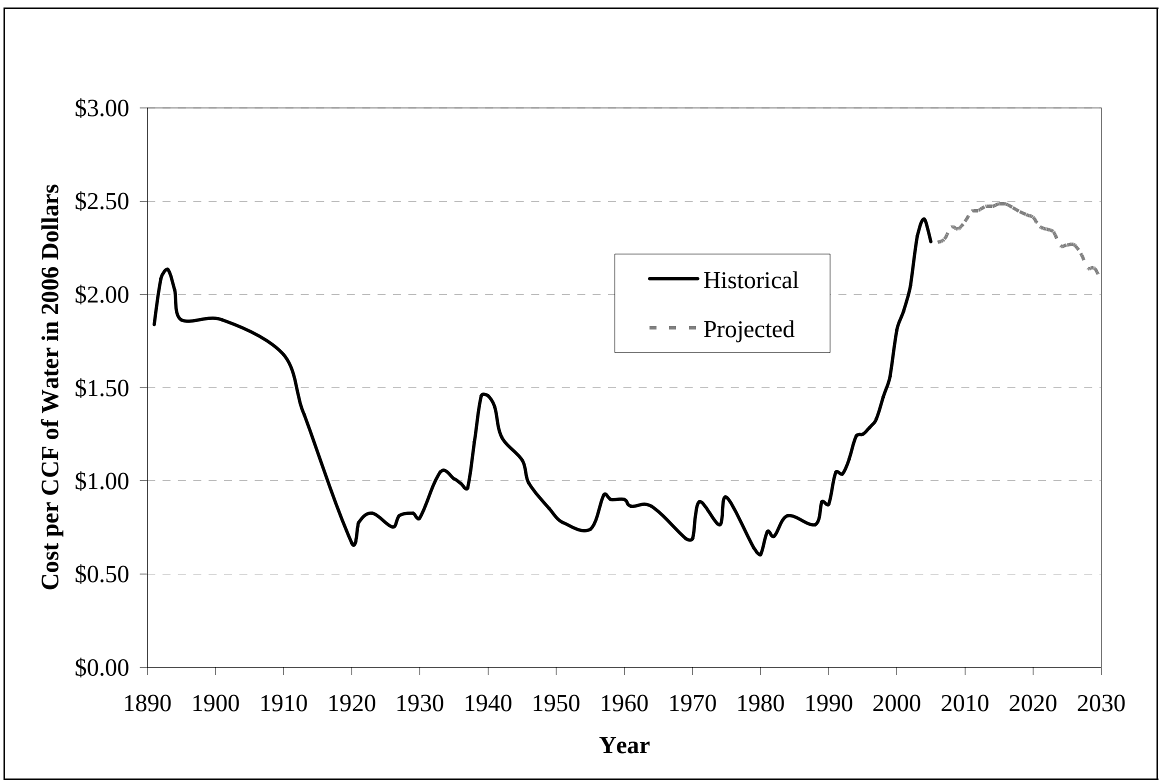


Figure 2-2. Average Rate per CCF of Water (2006 dollars)

Future rate levels depend on both the cost of providing water and the amount of water sold. With demand for water forecasted to generally decline through 2030, there will be no growth in water sales to absorb higher costs.

While rate forecasting is generally done for the system as a whole, there is a categorical difference between the rates paid by wholesale customers and the rates paid by retail service customers as shown in Figure 2-3.

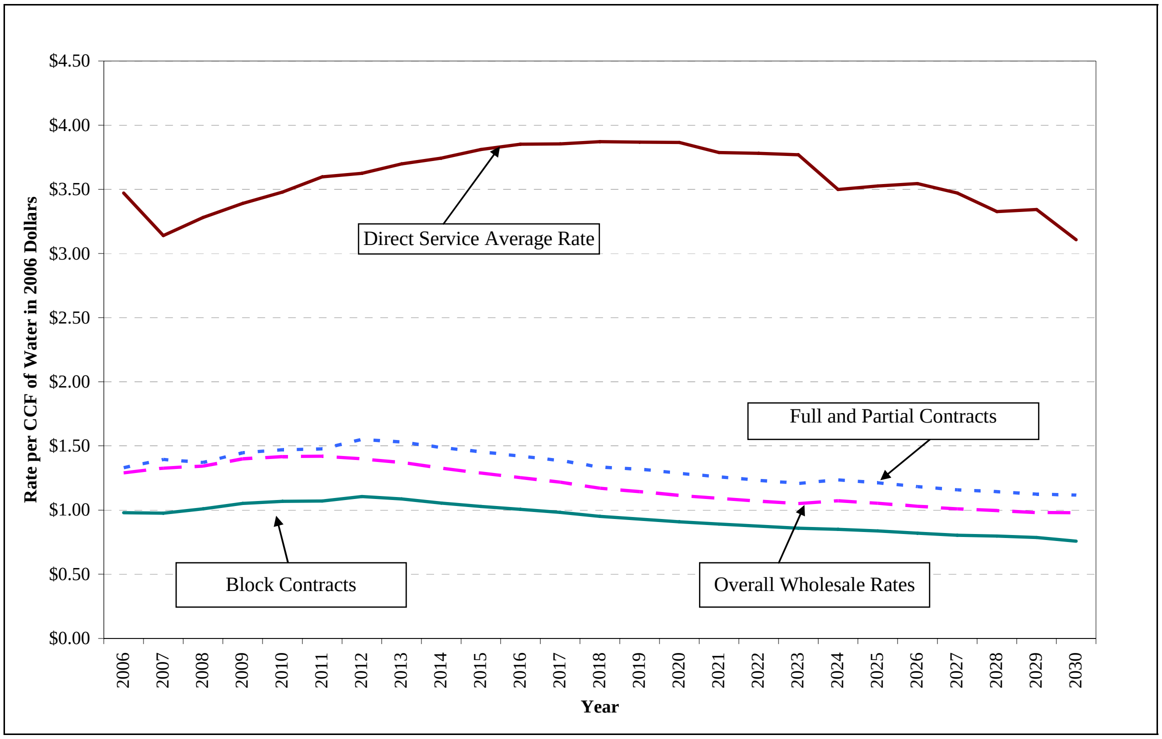


Figure 2-3. Comparison of Wholesale and Retail Water Rates

Wholesale customers do not pay for SPU's distribution system, since they are not served by these facilities. They pay only for their share of water supply, treatment, and transmission. The difference in projected rate paths shown in Figure 2-3 for retail and wholesale customers is due to the peak in regional capital projects budget occurring several years earlier than that for retail service area capital projects in the CFP. The rates charged by SPU's wholesale customers to *their* customers include the cost of the wholesale customer distribution systems. Most wholesale customers pay a set rate for a base water allowance ("Old Water") and a surcharge for consumption above that allowance ("Growth Charge"). Wholesale customers with block contracts pay a fixed amount regardless of the amount used, up to the block volume. Excess volume is charged at penalty rates for block contracts.

2.3.2 Debt Financing

From 2007 through 2030, 65 percent of the capital facilities plan (CFP) is expected to be financed with debt, as shown in Figure 2-4.

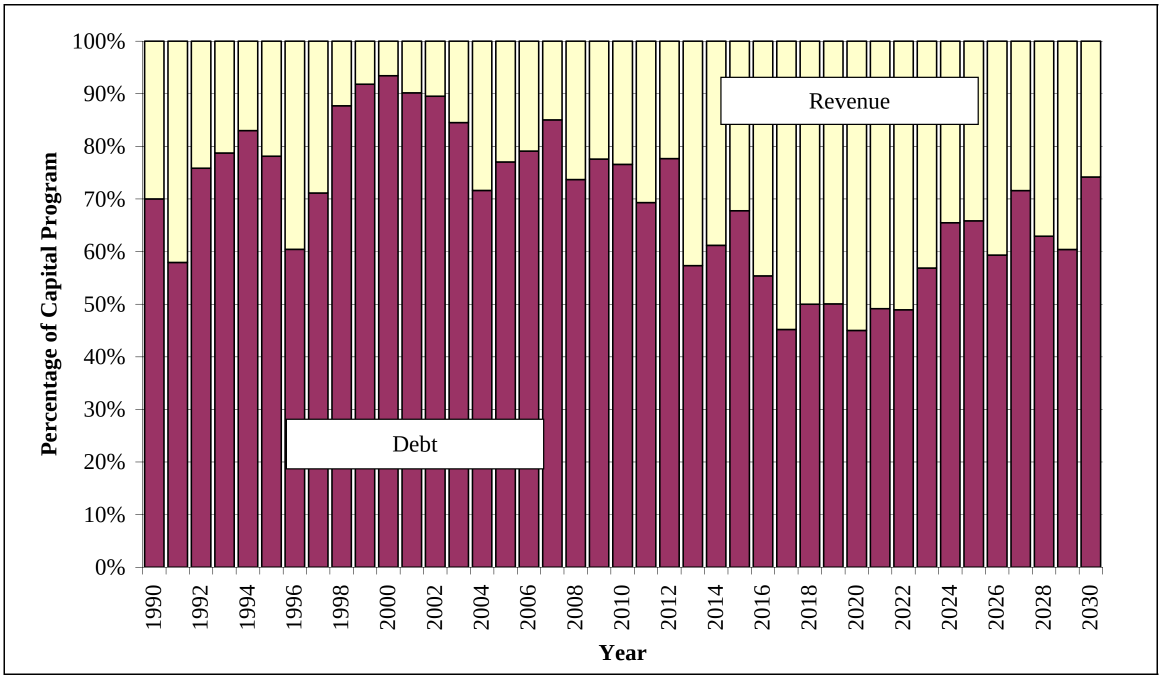


Figure 2-4. Past and Planned Debt Financing

Debt is expected to be used to finance 77 percent of the CIP through 2011 and 60 percent thereafter. The year-to-year variation in the use of debt will be caused by variation in the size of the capital program. In years where the capital program is small, available revenue will make up a larger percentage of the capital spending. When the capital program is large, debt will be relied upon more heavily.

2.3.3 Debt-to-Assets Ratio

SPU has been borrowing extensively and is expected to continue to borrow in large amounts in order to finance the capital program. This extensive use of debt means that the water system's debt-to-assets ratio has risen about 30 percent over the last 10 years and will peak at 74 percent in 2012 as shown in Figure 2-5.

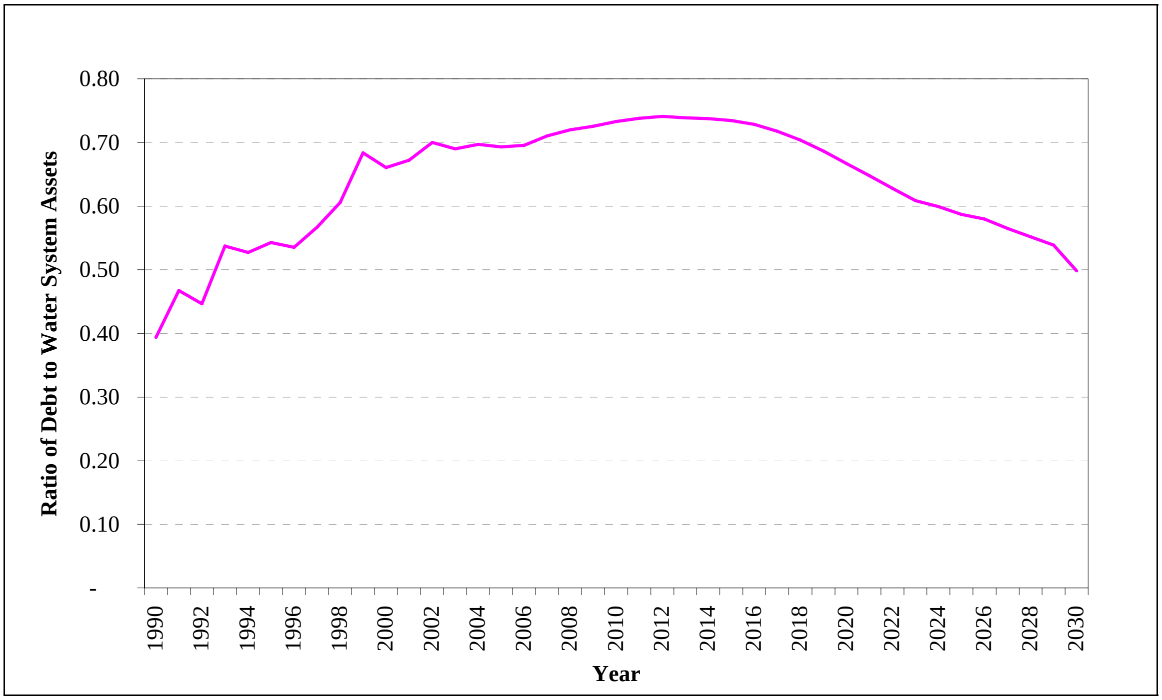


Figure 2-5. Past and Projected Debt-to-Assets Ratio

2.3.4 Alternative Financing Paths

A lower debt-to-assets ratio could be achieved more quickly by higher rate increases in the near-term, coupled with deferral of part of the capital program. This would allow a greater portion of the capital program to be financed out of revenues over time. However, it would also result in higher near-term rates, and deferring projects could prevent the water system from complying with regulatory agreements made with state and federal agencies. The proposed approach strikes a balance between short-term and long-term financing approaches, providing moderate rate increases over time, and addressing important capital and operating requirements.

2.3.5 Potential Financial Effects of Unanticipated Needs

Even with thoughtful consideration, it is often impossible to anticipate needs 20 to 30 years into the future. Future regulatory requirements or unexpected circumstances could require investments in addition to those included in the CFP. Retaining the financial flexibility to meet such unanticipated needs is an important part of planning for the future.

In order to judge the capacity of the water system to meet major unanticipated needs, a "what if" scenario was created. This scenario assumes that $10 million (in 2006 dollars) in additional capital spending would be required each year starting in 2015. Figure 2-6 shows the rate path required under this scenario.

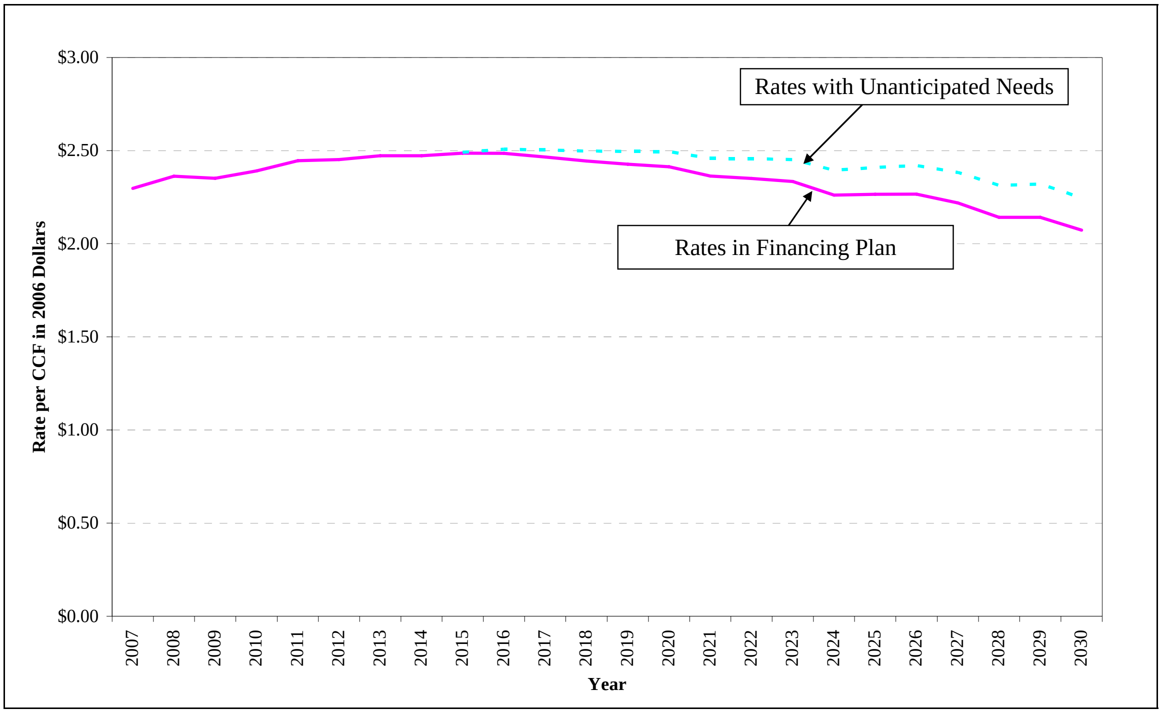


Figure 2-6. Effect of Unanticipated Needs on Average System Rates

The unanticipated needs would cause rates to decrease more slowly after 2015, in real terms, than they would without the unanticipated needs. Most of the additional capital spending for the unanticipated needs would be financed by debt.

As a result of the unanticipated needs in this scenario, debt would be used to fund about ten percent more of the CFP from 2015-2030. This additional reliance on debt financing would cause a small increase in the debt-to-assets ratio, which is already relatively high even without considering the unplanned needs scenario. Such an increase in the debt-to-assets ratio could cause SPU to incur even higher interest rates on future borrowing.

2.4 Financial Model Cash Flow Analysis

The capital improvements summarized in the Part II, Chapter 1, together with projected operating expenses through 2030, were incorporated into the water system's financial model in order to develop a long-term picture of rate requirements and financial performance. The anticipated cash flows and financial performance generated by the financial model are summarized at five-year intervals in Table 2-2.

Table 2-2. Summary of Water System Cash (in millions of dollars)

Revenue/Expenditures[1]	2010	2015	2020	2025	2030
Revenues					
Water Sales	163	196	219	226	229
Other (tap fees, interest income, operational grants, reimbursements, etc.)	12	13	15	16	17
Total revenues	175	209	233	242	246
Expenditures					
O&M	70	79	90	103	118
Taxes	27	33	38	40	41
Debt service	69	83	90	88	76
Revenue-financed construction	7	12	14	9	6
Total expenditures	173	207	233	241	241
Net revenue[2]	2	1	1	2	5
Debt Service Coverage	1.7	1.7	1.7	1.7	1.8
Debt-to-Assets ratio	0.73	0.73	0.67	0.59	0.50
Cash balance	6	7	8	9	10
Capital Facilities Financing	2007-2010	2011-2015	2016-2020	2021-2025	2026-2030
Revenue financing	26	52	65	59	54
Contributions in aid of construction	32	41	44	47	50
Debt financing	218	196	106	146	202
Total CFP financing	276	290	215	251	306

1 Actual dollars spent or received in any given year; revenues and expenditures are inflated to off-set the erosion of purchasing power over time due to inflation.

2 Revenues and expenditures do not net zero in this summary because of rounding errors, contributions to cash balances, and lags between when revenues are billed and when they are received

The rate of growth in cash expenditures is highest in the first half of the plan. During this period, capital expenditures are at their peak, with significant expenditures on such things as the reservoir covering and replacement program, improvements to the Chester Morse Lake Dead Storage facilities, and distribution infrastructure replacement. Some capital improvements could be deferred by SPU, thereby moderating the growth in rates in the early years. Large cash contributions to the capital improvement program will result in a reduction in debt service in later years. The debt-to-assets ratio is expected to peak in 2012 and decline steadily thereafter.

2.5 CONCLUSION

While SPU supply sources are projected to have adequate capacity for another 50 years or more, and SPU does not anticipate the need for additional water treatment improvements, significant capital investments in the system have been identified as needed. SPU has been making, and continues to make, significant investments to protect public health, comply with federal and state regulations, and replace aging infrastructure. In order to pay for the facilities, particularly to pay off debt for the new drinking water treatment and other facilities recently added to the system, customer rates will need to increase somewhat higher than the rate of inflation, until about 2015. After 2015, however, rates can be expected to stabilize and begin to decrease in real terms. This outlook positions SPU to meet unanticipated needs in the future to ensure reliable delivery of high quality water to its customers.

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