Seattle Public Utilities

2013 Water System Plan

Our Water. Our Future.

Volume I
July 2012

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VOLUME I

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Seattle Public Utilities
2013 Water System Plan

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Abbreviations

AMC	Asset Management Committee
AMR	Automated Meter Reading equipment
ASR	Aquifer Storage and Recovery
AWWA	American Water Works Association
BPA	Bonneville Power Administration
CCF	hundred cubic feet
CCL	Contaminant Candidate List
CCP	Concrete cylinder pipe
CCR	Consumer Confidence Report
cfs	Cubic feet per second
CFP	Capital Facilities Plan
CI	cast iron
CIP	Capital Improvement Program
COEHHA	California Office of Environmental Health Hazard Assessment
CRPL	Cedar River Pipeline
CUE	Conjunctive Use Evaluation
CWSP	Coordinated Water System Plan
DBP	Disinfection By-Products
DI	ductile iron
DNS	Determination of Nonsignificance
DSL	Distribution System Leakage
EDC	Endocrine Disrupting Compounds
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 Pipeline
GIS	Geographic Information System
GMA	Growth Management Act
HCP	Habitat Conservation Plan
HISB	High Impact Shutdown Block
I-63 SO	Initiative 63 Settlement Ordinance (Seattle Ordinance 120532)
IDSE	Initial Distribution System Evaluation
IFA	Instream Flow Agreement
IWA	International Water Association
LAF	Limited Alternative to Filtration
LEED	Leadership in Energy and Environmental Design
LIMS	Laboratory Information System

LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
LT2SWTR	Long Term 2 Surface Water Treatment Rule
MAC	Mycobacterium Avium Complex
MCL	Maximum Contaminant Level
MDL	Minimum Detection Limit
mgd	million gallons per day
MIT	Muckleshoot Indian Tribe
MTBE	methyl tertiary butyl ether
MWL	Municipal Water Law
NZMS	New Zealand mud snail
O&M	Operation and Maintenance
OFM	Washington State Office of Financial Management
PHSKC	Public Health Seattle and King County
PPCP	Pharmaceuticals and Personal Care Products
PRV	Pressure regulating valve
psi	pounds per square inch
PSRC	Puget Sound Regional Council
PUMA	Piloting Utility Modeling Applications
RCM	Reliability Centered Maintenance
RWSP	Regional Wastewater Services Plan
SAMP	Strategic Asset Management Plan
SBS	Standby Storage
SCADA	Supervisory Control and Data Acquisition
SDOT	Seattle Department of Transportation
SFD	Seattle Fire Department
SPU	Seattle Public Utilities
SRES	Special Report on Emission Scenarios
SWTR	Surface Water Treatment Rule
TESS	Tolt Eastside Supply
TESSL	Tolt Eastside Supply Line
TPL	Tolt Pipeline
UCMR	Unregulated Contaminant Monitoring Rule
UV	Ultraviolet
UW-CIG	University of Washington Climate Impacts Group
VOC	Volatile Organic Compounds
WAC	Washington Administrative Code
W.D.	Water District
WDOH	Washington State Department of Health
WSDOT	Washington Department of Transportation
WSP	Water System Plan
WTF	Water Treatment Facility
WUE	Water Use Efficiency

2013 Water System Plan
Plan Summary

Seattle Public Utilities (SPU) manages and operates the water system serving Seattle retail customers and wholesale customers in nearby cities and water districts. This *2013 Water System Plan* describes how SPU meets current and future water demands, ensures high quality drinking water, and invests in and maintains its water system at the lowest life-cycle cost. While the plan focuses on the 2013-2018 time period, longer term outlooks to 2040 and beyond are also discussed.

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 Rule, requirements of the Growth Management Act, and local and regional land use plans.

Key findings and implementation actions are highlighted below, with more detail provided in the chapters that correspond to the headings.

Drinking Water System

- SPU provides drinking water to a service area population of 1.3 million within the greater Seattle metropolitan region of King County and portions of southern Snohomish County. See map of SPU's service area on page S-9.
- Recent surveys of residential and commercial customers indicate that SPU's retail customers continue to be very satisfied with water system reliability and drinking water quality.

Water Resources

SPU's water supply system consists of surface water reservoirs on the Cedar River and South Fork Tolt River and two wellfields providing groundwater. The system is operated primarily for water supply and protection of instream flows, but also used for hydroelectric power generation and flood management.

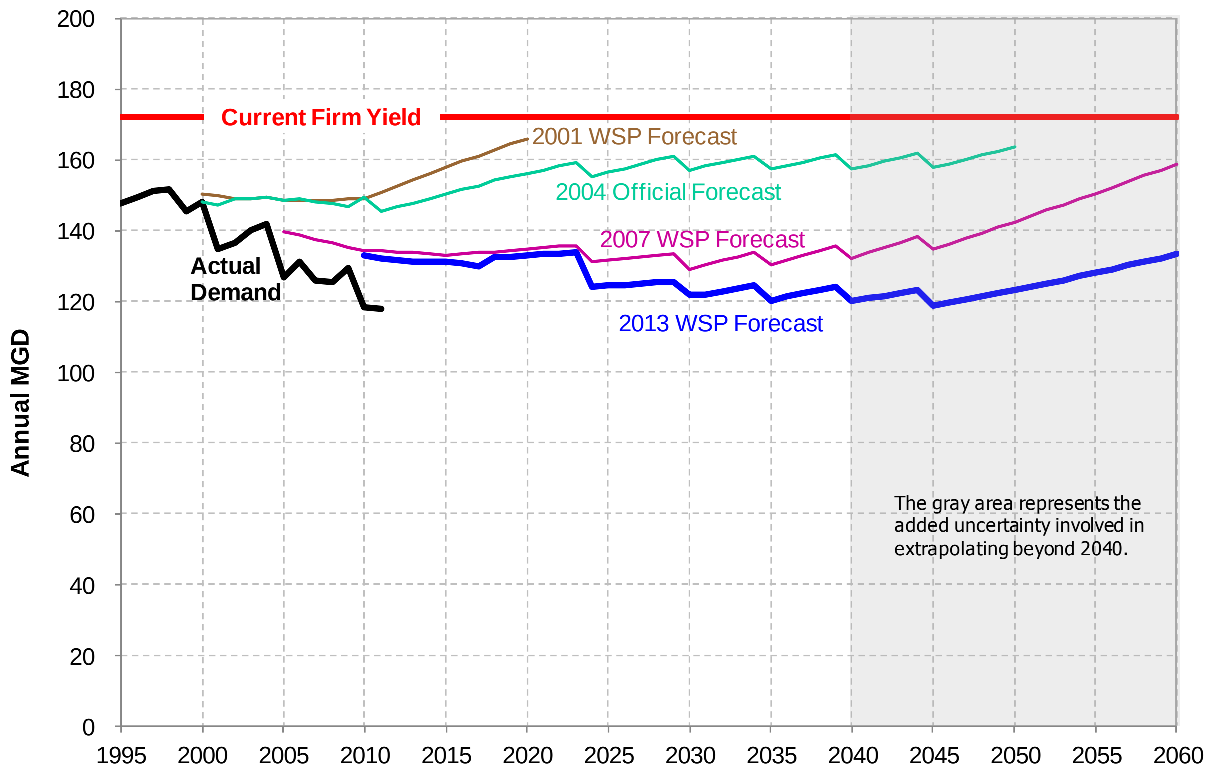
Water Use

- Approximately one-half of SPU's water is used by SPU's retail customers and one-half is sold through wholesale contracts to 19 municipalities and special purpose districts, plus Cascade

Water Alliance, who in turn provide the water to their own retail customers.

- Since 1990, consumption has decreased about 30 percent while population has increased by 15 percent.
- From 2010 to 2040, population is forecast to increase by 21 percent in SPU's retail service area and by 25 percent in the service area of SPU's full and partial wholesale water contract holders. Employment is forecast to grow by 54 and 46 percent, respectively, over the same period.
- Total average annual demand is forecast to remain at or below current levels of approximately 133 million gallons per day through 2060, significantly lower than what was forecasted in the *2007 Water System Plan*. See graph below.
- The primary factors that influence the demand forecast consist of the declining block contract with Cascade Water Alliance and continued reductions in water use by customers.

SPU's Official Water Demand Forecast



Conservation

- SPU achieved a greater than 30 million gallons per day (mgd), or 20 percent, reduction in water use on an average annual basis from 2000 through 2010 from the combined effect of the Regional 1% Conservation Program, SPU's "Everyone Can Conserve" Program, system operation improvements, and other changes in water use by customers due to rates and codes.
- This plan sets a goal to reduce per capita water use from current levels so that total average annual retail water use of members of the Saving Water Partnership[1] is less than 105 mgd from 2013 through 2018 despite forecasted population growth.

Water Supply

- The current firm yield estimate for SPU's water supply system is 172 mgd, which is an increase of one mgd reflecting recent demand patterns and a recently approved higher refill level in Chester Morse Lake.
- Through this plan, SPU is modifying its service area for its water rights place of use so as to clarify that the service area includes small areas in Snohomish County currently served by Northshore Utility District, the City of Woodinville, and the City of Bothell, as well as potential service area additions proposed by Water District 119. For these areas, see the map on page S-9.
- Given the new demand forecast and current firm yield estimate for SPU's existing supply resources, no new source of supply is needed before 2060.

Climate Change and Future Supply Outlook

- Updated analyses indicate that under the warmest climate change scenario analyzed, available supply is estimated to be reduced by as much as 4 percent in 2025, 6 percent in 2050, and 13 percent in 2075. Even so, the reduced supply would exceed climate-impacted demands for all years except 2075, in which demand would exceed supply by approximately 3 percent. Low or no cost system modifications could be made to meet demands in this case.

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[1] Members of the Saving Water Partnership include Seattle, Northshore Utility District and SPU's 17 full and partial wholesale water contract holders.

Planned Infrastructure and Operational Improvements

- SPU identified infrastructure improvement needs for the water supply system that include Morse Lake Pump Plant, Overflow Dike Replacement, and Landsburg Dam Flood Passage Improvements projects.
- SPU plans to complete investigations that support water resources operations including refill of Chester Morse Lake to elevation 1566 feet, potential impact on water quality that could be caused by failure of Lake Youngs Cascades Dam, and potential additional drawdown of South Fork Tolt Reservoir.

WATER QUALITY AND TREATMENT

SPU's water system includes state-of-the-art water treatment facilities for the Cedar and South Fork Tolt source waters, in-town disinfection facilities at reservoirs and well sites, and a state-certified water quality laboratory.

Drinking Water Quality

- SPU continues to meet drinking water quality regulations and other aesthetic criteria (i.e., taste and odor).
- SPU's source protection practices, water treatment facilities, and distribution system practices have provided excellent quality water that ensures compliance with current and future regulations.
- Results of testing in 2008 for pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) in SPU's source water confirms the absence of these emerging contaminants of concern.
- SPU plans to review distribution system flushing practices and the level of resources allocated to flushing of the distribution system through fire hydrants.
- SPU will conduct a risk-cost analysis of public access on the Kerriston Road to determine if additional land acquisition is the preferred approach for mitigating the risk of impairing Cedar source water quality.
- SPU will continue to monitor and characterize limnological conditions in Lake Youngs as it affects Cedar supply operations and treated water quality.
- SPU will operate the water supply system to bypass Lake Youngs to avoid problematic algae from entering the water system.

- SPU will continue efforts to prevent aquatic nuisance and invasive species from being introduced into SPU's drinking water supplies.

Reservoir Covering/Burying

- SPU has covered eight of the ten reservoirs that were previously uncovered, with six of these buried to increase security and create new public open space opportunities.
- The plan for the remaining two open reservoirs is to test-decommission Roosevelt Reservoir and Volunteer Reservoir.
- In about 2020, the floating covers on Bitter Lake and Lake Forest Park Reservoirs will be evaluated for their remaining service life and possible replacement.

Water Treatment Facilities

- SPU will be evaluating contract extension options for the Tolt and Cedar Water Treatment Facilities that are in long-term Design-Build-Operate (DBO) contracts.
- SPU plans to replace the existing gas chlorine feed system at Landsburg with sodium hypochlorite to reduce safety risks.

WATER TRANSMISSION SYSTEM

The regional and sub-regional water transmission systems include approximately 193 miles of pipeline, seven covered reservoirs, 15 pump stations, six elevated tanks and standpipes, and 129 wholesale customer taps with meters.

Transmission Infrastructure

- SPU has met the wholesale contract requirements for pressure and flow, and there have been no unplanned outages of the transmission pipelines that have exceeded SPU's service level for maximum outage durations.
- SPU plans to mitigate the risk of pipe failure in the slide area between the Regulating Basin and Tolt Water Treatment Facility through continued slope monitoring, additional geotechnical data collection, periodic internal inspections, biannual leak testing, and by taking such actions as acquiring ownership of the land in the slide area and implementing pipeline stress relief measures when necessary.
- SPU will implement cost-effective cathodic protection projects as needed for the concrete cylinder and steel transmission

pipelines to protect these from corrosion and extend their service lives.

System Storage Level of Reliability

- SPU has defined its system storage level of reliability that is based on outage scenarios of major system components and of power supply. These scenarios form the basis for downsizing or retiring certain treated water reservoirs, for decommissioning certain tanks and standpipes, and for making targeted improvements to pump stations.

WATER DISTRIBUTION SYSTEM

The distribution system contains more than 1,680 miles of watermains, two open reservoirs, six covered reservoirs, 16 pump stations, six elevated tanks and standpipes, 21,000 valves, and 18,920 fire hydrants, as well as more than 188,000 service lines and meters serving individual residential and non-residential properties in the retail service area.

Service Delivery

- Since completion of the pressure improvement projects in early 2009, pressures at all retail service connections are greater than 20 pounds per square inch during normal operations.
- SPU consistently responded to reported distribution system problems within one hour more than 90 percent of the time.
- While SPU's distribution system leakage has increased from less than 3 percent in 2006 and 2007 to more than 6 percent in 2010 and 2011, the 3-year rolling average has remained below the WDOH standard of 10 percent.
- The rate of watermain leaks and breaks remains low, averaging less than 10 reported leaks or breaks per 100 miles per year in the distribution system.
- From 2006 through 2010, fewer than 2 percent of all retail customers experienced water service delivery outages of more than 4 hours per year from all planned and unplanned events.

Distribution Infrastructure

- SPU plans to assess, in a pilot effort, the condition of a portion of the most critical watermain segments and, if needed and supported by analysis, to repair, rehabilitate or replace the pipe prior to anticipated failure.

- SPU will improve operational response and customer service by using information from the watermain shutdown block analysis for project and emergency shutdown plans.
- SPU plans to complete the remaining seismic backbone upgrades in the Duwamish River Valley.
- SPU will consider the use of cleaning and cement-mortar lining as an alternative to replacement of deteriorated unlined, cast iron pipe to address pipeline life, fire flow, water quality, and pressure issues in the distribution system.
- SPU will continue to work with the Seattle Fire Department to improve fire hydrant maintenance and testing practices, to better coordinate communication between SFD and SPU's water system control center and emergency crews just prior to and during fire fighting, and to prioritize and implement fire flow improvement projects.
- SPU plans to use SPU's Watermain Replacement Opportunity Model to determine whether to protect or replace existing watermains impacted by transportation projects.
- SPU will continue working with developers where watermain replacements or upgrades in redevelopment areas are required to meet current fire flow requirements and watermain standards.

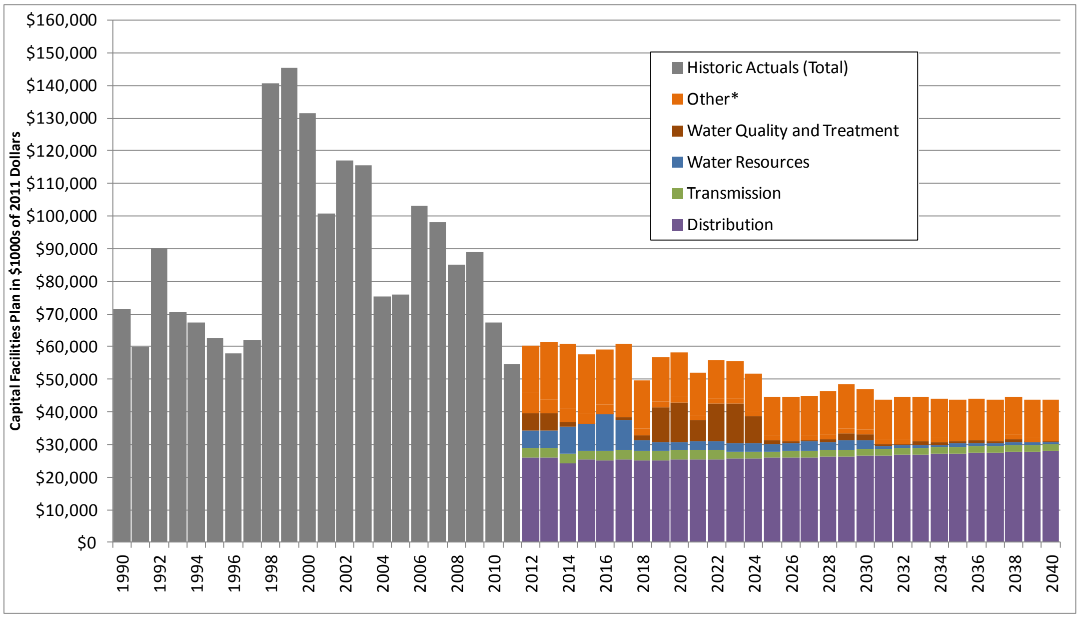
PLAN IMPLEMENTATION

Implementation of this plan requires completion of capital projects, programs, and operations and maintenance (O&M) activities.

Capital Facilities Budget

- Over the past decades, SPU has invested in several major new capital projects, including the two new water treatment facilities and Tolt Pipeline 2.
- SPU anticipates its capital improvement budget needs to be much lower than in the past decades, and will decline from $62 million in 2013 to less than $45 million by 2025, and remain at approximately that level through 2040 (in 2011 dollars). See the graph on page S-8 for historic and proposed capital expenditures.
- SPU's draft Capital Facilities Plan totals to $1.4 billion from 2013 through 2040, which is 64 percent of what was spent in the previous 28-year period (in 2011 dollars).

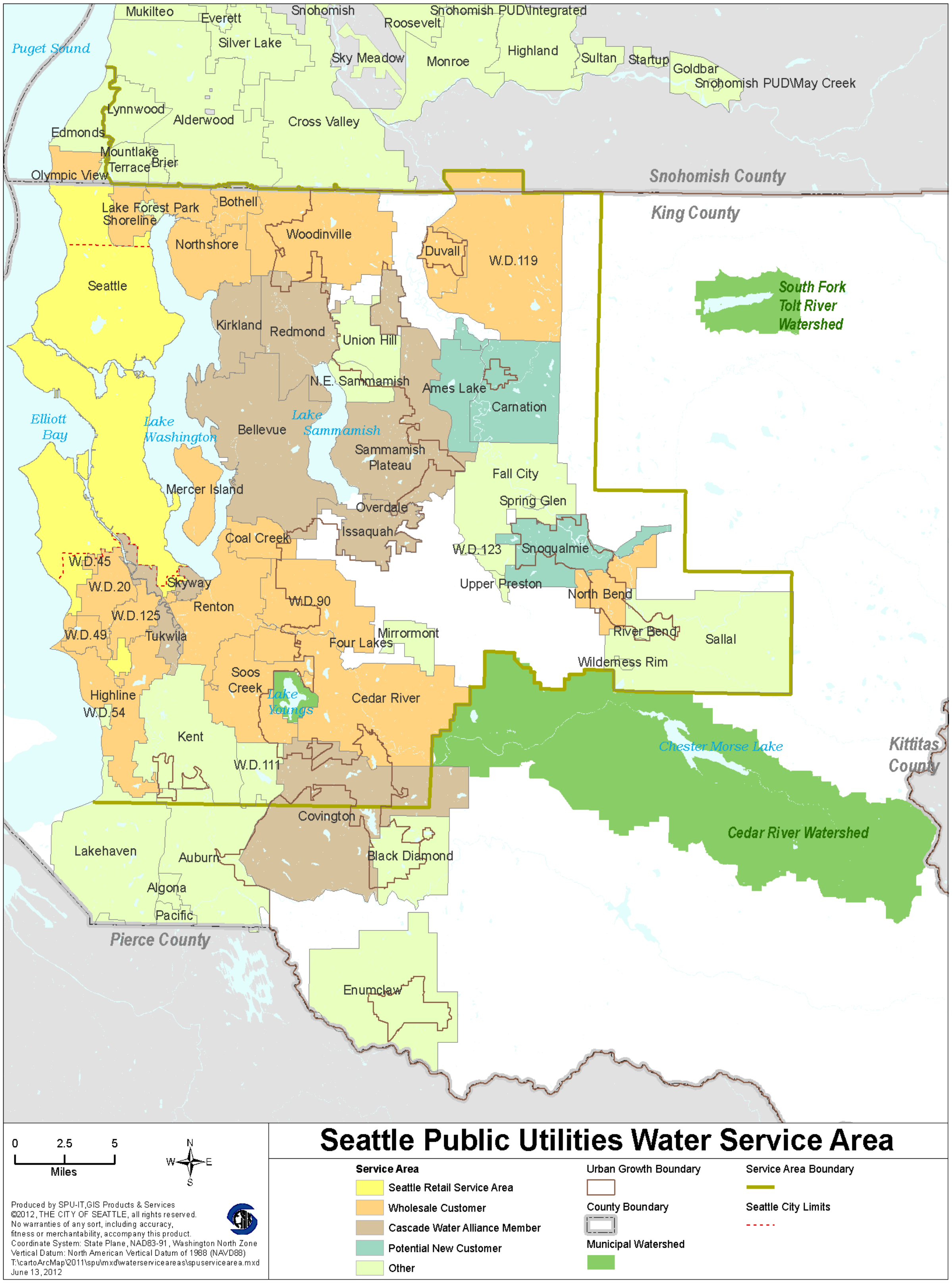
**Historic and Proposed Capital Facilities Plan Spending through 2040
(2012-2017 Adopted CIP, plus 2018-2040 Estimates, in thousands of 2011 dollars)**



* Other includes Major Watersheds, Fleets, Facilities, Security, Information Technology, SCADA and other miscellaneous projects.

CONCLUSION

SPU has been making, and continues to make, significant investments to protect public health, comply with federal and state regulations, and replace aging infrastructure. While SPU has invested in major regional facilities in the past decades, the need is now shifting to significant capital investments to rehabilitate and improve the distribution system. Implementation of this water system plan will help to ensure that SPU meets its mission to provide reliable, efficient and environmentally conscious water utility services to enhance the quality of life and livability in all communities we serve.


Seattle Public Utilities Water Service Area
Puget Sound
Mukilteo
Everett
Snohomish
Snohomish PUD\Integrated
Roosevelt
Silver Lake
Sky Meadow
Monroe
Highland
Sultan
Startup
Goldbar
Snohomish PUD\May Creek
Lynnwood
Alderwood
Cross Valley
Edmonds
Mountlake Terrace
Brier
Olympic View
Snohomish County
King County
Lake Forest Park
Bothell
Shoreline
Northshore
Woodinville
Duvall
W.D.119
South Fork Tolt River Watershed
Seattle
Kirkland
Redmond
Union Hill
N.E. Sammamish
Ames Lake
Carnation
Elliott Bay
Lake Washington
Lake Sammamish
Bellevue
Sammamish Plateau
Mercer Island
Fall City
Spring Glen
Overdale
Issaquah
Coal Creek
W.D.123
Snoqualmie
W.D.45
Skyway
Upper Preston
North Bend
W.D.20
W.D.90
Renton
W.D.125
Mirrormont
River Bend
Sallal
W.D.49
Tukwila
Four Lakes
Wilderness Rim
Soos Creek
Lake Youngs
Cedar River
Highline
W.D.54
Chester Morse Lake
Kittitas County
Kent
W.D.111
Covington
Cedar River Watershed
Lakehaven
Auburn
Black Diamond
Algona
Pacific
Pierce County
Enumclaw
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Miles
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Coordinate System: State Plane, NAD83-91, Washington North Zone
Vertical Datum: North American Vertical Datum of 1988 (NAVD88)
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June 13, 2012
Service Area
Seattle Retail Service Area
Wholesale Customer
Cascade Water Alliance Member
Potential New Customer
Other
Urban Growth Boundary
County Boundary
Municipal Watershed
Service Area Boundary
Seattle City Limits

The entire *2013 Water System Plan* may be found at:
www.seattle.gov/util/WaterSystemPlan

Part I: Direction for Business Areas

Part I of this *2013 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 2040.

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Chapter 1 Introduction

Seattle Public Utilities (SPU) provides drinking water to a service area population of 1.3 million within the greater Seattle metropolitan region of King County and portions of southern Snohomish County. This *2013 Water System Plan* describes the near- and long-term plans for the regional water system in accordance with Washington State Department of Health (WDOH) requirements. The focus of this plan is on updates to the water system and programs since completion of the *2007 Water System Plan*. To provide context for this plan, this introductory chapter includes a brief history and description of the existing water system and of five core business areas that comprise SPU's water line of business.

In addition, this chapter presents an overview of SPU's policies that guide activities for the water system. A summary is provided of SPU's customer service levels for the water system. Also provided are the results of recent customer surveys regarding their views on the quality of services provided by SPU. The chapter also contains a description of the current planning environment, including how this plan is consistent with other relevant planning efforts. Finally, the introduction summarizes the organization of this plan and describes how it meets the requirements of the Washington Administrative Code (WAC).

1.1 SPU's Drinking Water Line of Business

SPU's mission is to provide reliable, efficient and environmentally conscious utility services to enhance the quality of life and livability in all communities we serve.

The overarching mission for SPU is to provide reliable, efficient and environmentally conscious utility services to enhance the quality of life and livability in all communities we serve. 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 60 to 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.

Although the City began developing its water rights on the Tolt River in 1936, the source was first put 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 to 40 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 664,000 people in its retail service area and provides water to 20 wholesale customers, including Cascade Water Alliance, who together deliver SPU water to an additional residential population of over 629,000. 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 1,880 miles of transmission and distribution system pipelines. SPU also provides untreated water from the Cedar River Watershed to North Bend to mitigate streamflow impacts to their water supplies. SPU is not a Satellite System Management Agency, and will not operate nor be responsible for Group A water systems owned by other parties, even if these are within the City of Seattle. 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.

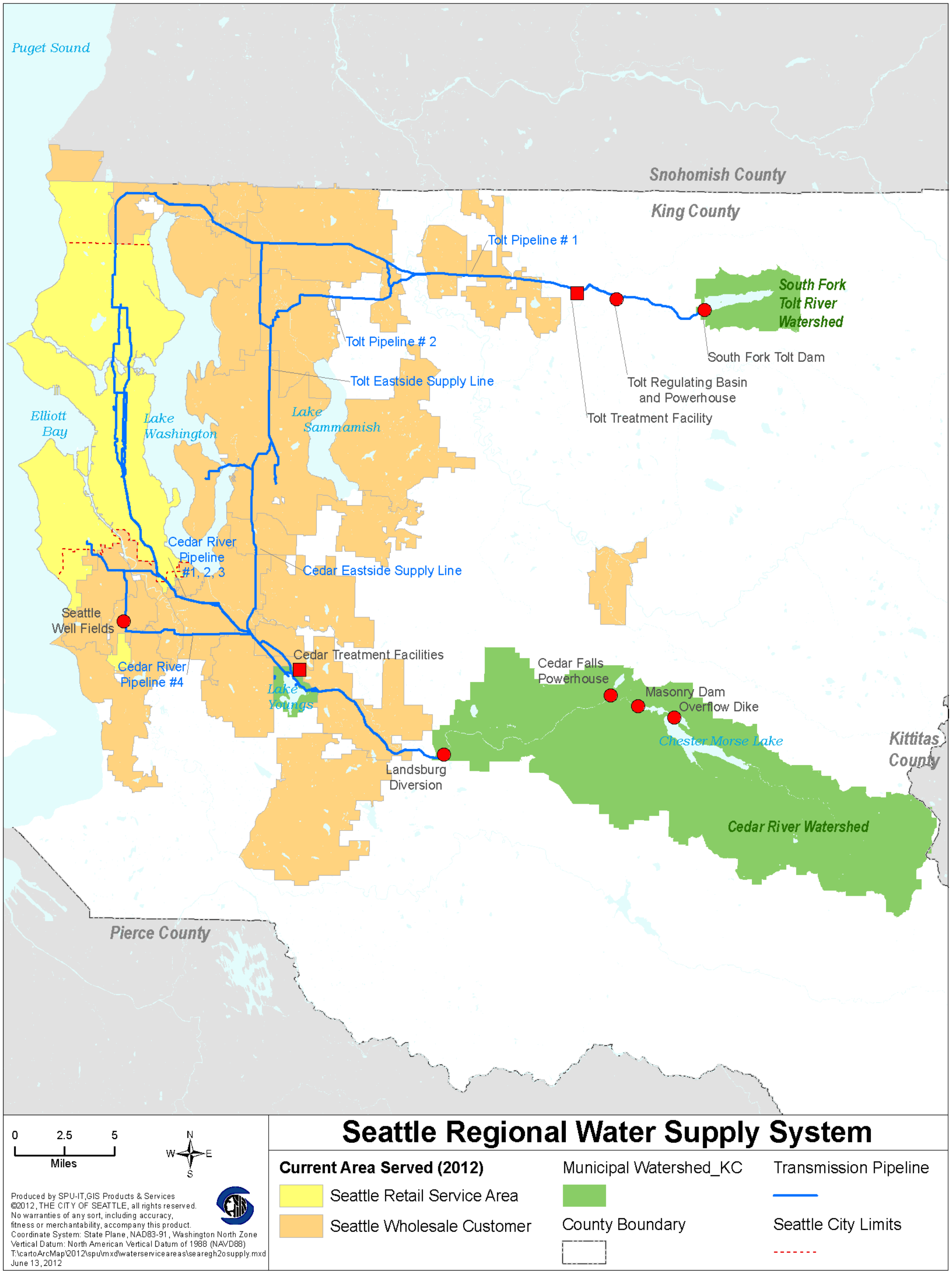

Figure 1-1. Seattle Regional Water Supply System

1.1.3 Business Areas

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

SPU's water line of business is divided into five core business areas[1] that are focused on key components or sub-systems of its water system. These consist of Major Watersheds, Water Resources, Water Quality and Treatment, Transmission, and Distribution. In addition to the core business areas, there are business areas that are common to and shared by the lines of businesses other than water within SPU. These include Technology, Supervisory Control and Data Acquisition (SCADA), Security, Fleets and Equipment, and Facilities. By organizing the line of business in this manner, SPU is better able to articulate the performance objectives of each sub-system and create accountability in meeting those objectives. The core business areas are described more fully below.

1.1.3.1 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, the Cedar River Watershed Habitat Conservation Plan (HCP), the Tolt Watershed Management Plan, the Bonneville Power Administration (BPA) settlement agreement implementation, the Muckleshoot Indian Tribe agreement implementation, watershed stewardship (including Cedar River Watershed 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. The business area also provides coordination with salmon recovery plans. 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 *2013 Water System Plan* since such a summary is not required by WDOH.

1.1.3.2 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

[1] The *2007 Water System Plan* listed four business areas, but the Transmission and Distribution business areas has been split in two since then.

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.

1.1.3.3 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. Critical water quality monitoring and regulatory compliance services are provided to the Water Quality and Treatment business area by SPU Laboratory Services Division. Infrastructure in this business area includes the Tolt and Cedar Water Treatment Facilities and ancillary facilities, Landsburg treatment and intake screening facilities, and in-town water treatment facilities at reservoirs and well sites. Key Operations Programs in the Water Quality and Treatment business area include water treatment facility operations, cross-connection control, and storage facility cleaning.

1.1.3.4 Transmission Business Area

The Transmission business area is comprised of programs and projects affecting the regional and sub-regional transmission systems, which serve both SPU and its wholesale customers. Business area activities include policy development, planning and oversight for transmission pipelines, and operation and maintenance of the transmission headworks and pipelines, storage facilities, pump stations, wholesale customer taps, and appurtenances. The Transmission business area provides oversight for and coordination with related programs, such as seismic analysis and cathodic protection. Billing meter and transportation-related projects that impact both the water transmission and distribution systems are overseen by the Transmission business area manager.

1.1.3.5 Distribution Business Area

The Distribution business area is comprised of programs and projects affecting the distribution system, which serves SPU's own retail customers within and outside the City of Seattle. Business area activities include policy development, planning and oversight for distribution pipelines, and operation and maintenance of distribution pipelines, storage facilities, pump stations, hydrants, valves, services and miscellaneous appurtenances.

1.2 GUIDING POLICIES

Revised and updated polices for SPU's water business areas were developed and adopted for the *2007 Water System Plan*, and are being carried forward in this plan. These policies are summarized in the table below.

Table 1-1. 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 most recent *Water System Plan*, allowing for new wholesale 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.

1.3 Customer Service Levels and Survey Results

SPU first documented its service levels objectives and targets in its *2007 Water System Plan*. Since then, SPU has tracked its performance relative to those targets. These efforts are part of SPU's asset management initiative as outlined in the *2007 Water System Plan*.

In addition, SPU has completed a series of surveys of its residential and commercial customers to get feedback on the services SPU provides.

1.3.1 Service Levels

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

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 outcomes. Service levels are used by SPU to manage its assets, including making decisions on renewal/ replacement and O&M practices.

The *2007 Water System Plan* provided levels of service targets to achieve the following objectives:

- Meet the environmental requirements of our water rights and water supply operations.
- Meet water use efficiency goals to ensure wise use and demonstrate good stewardship of limited resource.
- Promote a high level of public health protection and customer satisfaction with drinking water quality.
- Provide agreed-upon service to wholesale customers.
- Provide adequate pressure for drinking water supplies.
- Respond quickly and effectively to water distribution system problems.

For the most part, SPU has been meeting the service level targets since 2006. More information is provided in the chapters that follow.

1.3.2 Customer Surveys

Survey results indicate that SPU's customers are very satisfied with water system reliability and drinking water quality.

SPU conducts periodic surveys of its residential and business customers to gather their opinions and views of the utility services it provides within the City of Seattle. These surveys provide performance measurements which are used as part of SPU's performance management program. They also provide information on how well the utility is meeting customers' utility needs and on special topics of particular relevance in the survey year.

SPU surveyed residential customers within the City in 2001, 2003, 2005, 2007 and 2011. In these surveys, a random sampling of residential customers was selected to represent the City's residential demographic profile. These customers were asked to rate their level of satisfaction with the City's water supply and with drinking water quality on a seven-point scale, where "1" means "not at all satisfied" and "7" means "very satisfied." Most respondents rated these services as "6" or "7 - very satisfied." The mean satisfaction scores for each year are shown in Figure 1-2 and indicate a high and generally increasing level of satisfaction with both of these utility services.

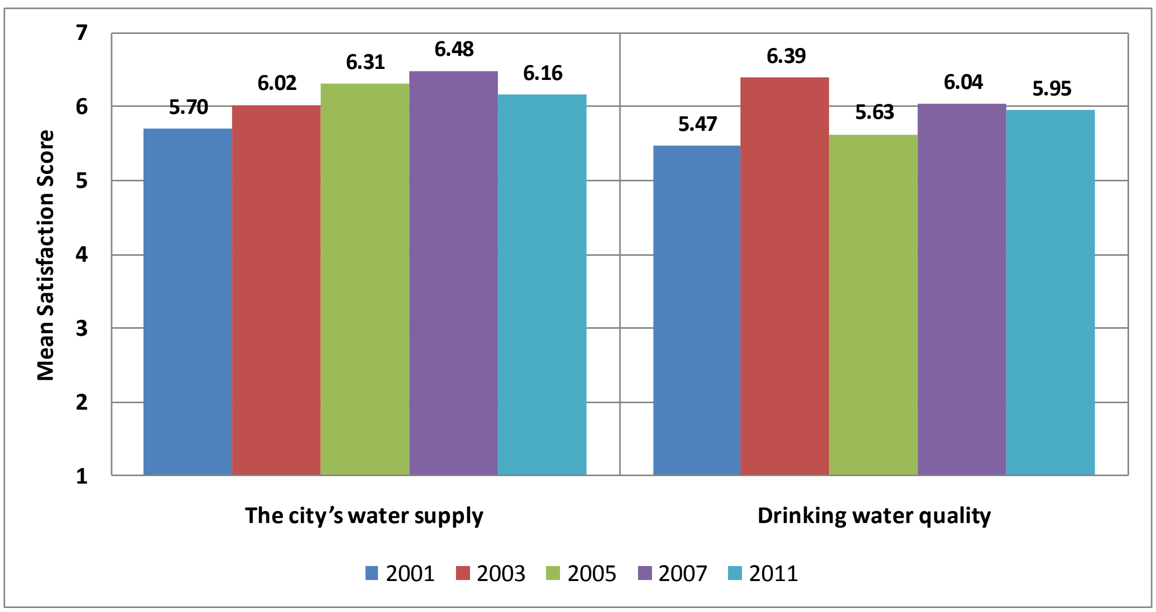

Figure 1-2. Residential Customer Survey Results for Water Supply and Quality

Surveys of SPU's business customers within the City – both small and large – were conducted in 2004, 2006, 2008 and 2011. These customers were asked to rate their satisfaction with the reliability of water service and drinking water quality, using the same seven-point scale as residential customers. The mean satisfaction scores for each year are shown in Figure 1-3 and indicate a high and generally increasing level of satisfaction with both of these utility services.

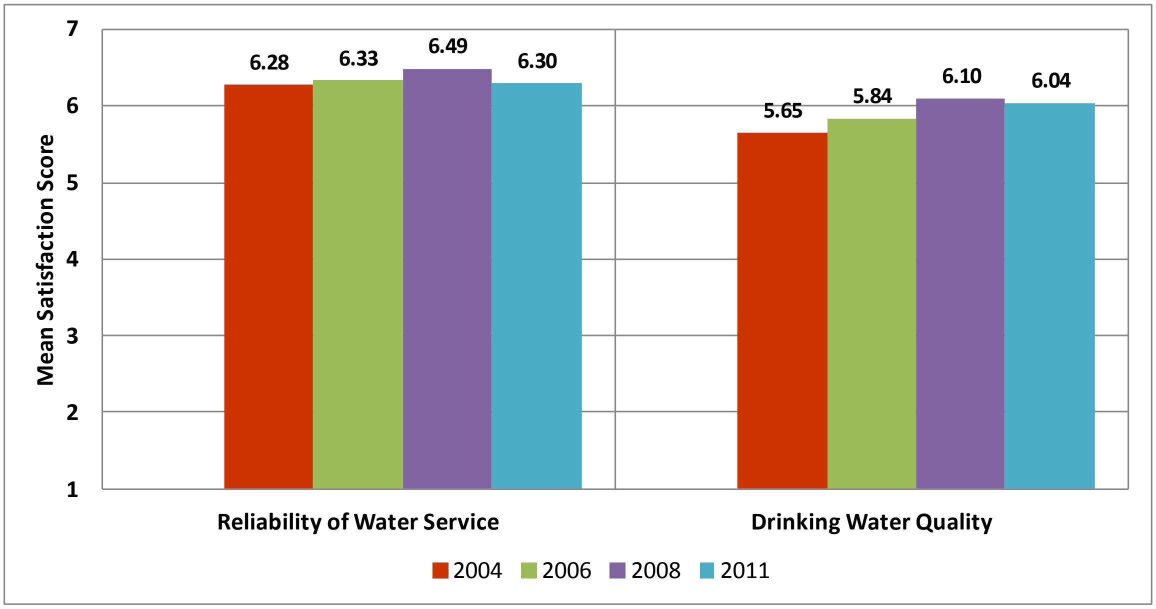

Figure 1-3. Business Customer Survey Results for Water Supply and Quality

In 2011, residential customers were also asked a series of questions regarding the taste of Seattle's drinking water and their water drinking habits. Fifty-two percent of all respondents report their tap water tastes "excellent" or "very good," and only five percent reported it tastes "poor." For those who drink tap water that they do not filter in their home, most (44 percent of all respondents) rate the taste of their tap water even higher: 63 percent rated their water as "excellent" or "very good," and only one percent as "poor."

These survey results indicate that SPU's customers are very satisfied with water system reliability and drinking water quality.

1.4 Planning Requirements

The SPU regional water system is categorized as a Group A community water system with 1,000 or more services and must prepare a water system plan for Washington State Department of Health review and approval per Chapter 246-290-100 of the Washington Administrative Code (WAC). These plans must be updated and submitted every six years. This section describes the planning requirements, as well as how this plan is consistent with other plans.

Note that this water system plan does not cover the Group A water system at Seattle's Cedar Falls Headquarters. That system, as well as other water systems serving outlying SPU facilities, has a separate operating permit and different planning requirements.

1.4.1 WSP Requirements

According to the WAC, the purposes of water system plans (WSPs) 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). 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.

The WAC also provides for a "document submittal exception" process that allows a purveyor to proceed with new distribution mains without submitting construction documents to WDOH for review. This process requires a WDOH-approved water system plan that includes standard construction specifications for these types of projects. SPU is requesting such an exception for new distribution mains. Information needed to support this request is provided in the appendices, including SPU's design and construction guidelines.

WAC 246-290-108 requires that this *Water System Plan* be consistent with local plans and regulations. Consistency review and certification have been obtained from those local governments with jurisdiction over areas where SPU provides retail water service, which includes the cities of Seattle, Shoreline, Lake Forest Park and Burien (see appendix). This consistency review covers:

(a) Land use and zoning within the applicable service area;

(b) Six-year growth projections used in the demand forecast;

(c) Utility service extension ordinances of a city or town when water service is provided by the water utility of the city or town;

(d) Provisions of water service for new service connections; and

(e) Other relevant elements related to water supply planning as determined by WDOH.

King County has its own consistency review process.

1.4.2 Consistency with Other Plans

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

In planning to meet future demand, it is necessary to coordinate with other planning efforts to ensure consistency. WDOH has determined that plans that may contain elements requiring local government consistency review include Coordinated Water System plans, Regional Wastewater Plans, Reclaimed Water Plans, Groundwater Area Management Plans, and Capital Facilities Elements of Comprehensive Plans. Other plans that SPU coordinates with include the water system plans of SPU's wholesale customers and adjacent water purveyors, watershed plans and salmon recovery plans. Each of these plans and their relevance to SPU's water resources and water system planning is described below.

1.4.2.1 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.) A small portion of SPU's retail service area lies within the Skyway/Bryn Mawr Critical Water Service Area. 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.

1.4.2.2 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 Water Alliance because SPU is not involved with Cascade planning in these areas.

Since the *2007 Water System Plan,* SPU has reviewed or provided input and comments on water system plans from Bothell, Cedar River, Duvall, Edmonds, Highline, North Bend, Northshore, Olympic View, Redmond, Shoreline Water District, Woodinville, and Water Districts 20, 45, 49, 90, and 125. SPU will continue working closely with wholesale customers to coordinate regional water supply planning activities.

1.4.2.3 King County Comprehensive Plan

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. These areas are located south of the City of Seattle boundary and form portions of the North Highline and West Hill Potential Annexation Areas. In total, fewer than 4,800 customers are located in unincorporated King County.

SPU's *2013 Water System Plan* aims to be consistent with the *King County Comprehensive Plan* (*KCCP*) 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 *2013 Water System Plan* is consistent with the policies in the *KCCP* relevant to water supply.

1.4.2.4 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 *Comprehensive Plan* is undergoing a major review to reflect a 20-year vision for the Seattle community. Part of the review will be to ensure that Seattle's *Comprehensive Plan* remains consistent with the regional growth management strategy (Vision 2040) and the King County Countywide Planning Policies which were recently revised. As with the *KCCP*, SPU has closely monitored development of the Seattle's *Comprehensive Plan* to ensure that this water system plan will be consistent with it.

1.4.2.5 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 2006.

1.4.2.6 Purveyors Beyond the Boundaries of SPU's Service Area

As a regional water supplier, SPU was an active participant in the *2009 Water Supply Outlook*, produced by the Water Supply Forum for the three-county region of Snohomish, King, and Pierce Counties. SPU continues to be an active member on the Forum, which 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.

1.4.2.7 Regional Wastewater and Reclaimed Water Plans

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 has been actively involved in the development of the King County Reclaimed Water Comprehensive Plan.

King County has indicated that completion of their Reclaimed Water Checklist suffices to meet consistency with these plans. This checklist is included in the appendices.

1.4.2.8 Groundwater Area Management Plans

The Seattle Well Fields and a portion of SPU's retail service area lie within the South King County Groundwater Management Area. However, there are no approved groundwater area management plans applicable to SPU.

1.4.2.9 Watershed Plans

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

Watershed plans in the SPU retail service area are the 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 adopted as part of the Puget Sound Salmon Recovery Plan, approved by the federal government in 2007. This watershed planning occurred within the framework of RCW 77.85, Salmon Recovery. This is not one of the types of plans for which a water system plan must meet WDOH consistency requirements.

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

1.4.2.10 Salmon Recovery Plans

Seattle participates in salmon recovery processes conducted under the framework of RCW 77.85 in the Water Resource Inventory Areas (WRIA) associated with its water supply and service area: WRIAs 7 (Snohomish River Basin), 8 (Cedar River/Lake Washington Basin), and 9 (Green River/Duwamish Basin). The WRIA 7, 8, and 9 salmon recovery 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 supported salmon recovery through primary sponsorship and implementation of significant habitat restoration and protection projects, and has also addressed salmon habitat protection through its land use and public outreach policies and programs.

As part of WRIA 7, 8, and 9 salmon recovery efforts, Seattle has been a leader in implementing a number of actions. Examples of these efforts include:

- Lower Cedar River habitat acquisition and restoration projects.
- Shoreline and wetland restoration projects along the south shoreline of Lake Washington.
- Development and distribution of a Green Shorelines Guidebook for Lake Washington property owners.
- Receipt of an EPA grant in 2010 to develop Green Shorelines Incentives.
- Receipt of an EPA grant in 2010, partnering with Cascade Land Conservancy and Friends of Cedar River Watershed to eradicate knotweed and replant native plants on public and private property in lower Cedar River; and conduct community outreach and education on river and stream restoration.
- Purchase and restoration 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.
- Implementation and primary fiscal sponsorship of the Tolt River Floodplain Reconnection Project, in partnership with King County and multiple grant funders.
- Funding over several years to Tulalip Tribes for juvenile salmon research on the Snoqualmie River.
- Protective land management practices in the Seattle-owned, Cedar River Municipal Watershed to preserve water quality and the natural ecological processes that promote healthy river conditions throughout the Cedar River Basin.

- Fish passage facilities at the Landsburg Dam that reopen over 20 miles of stream habitat for salmon in the protected Cedar River Municipal Watershed.

- Protective stream flow management practices that provide beneficial stream flows for all salmon and steelhead life stages in the Cedar and South Fork Tolt rivers.

- Implementation of the new Cedar River Sockeye Salmon Hatchery Program and associated Adaptive Management Plan guided by oversight bodies composed of representatives from federal, state, tribal and local natural resource agencies, academic experts and citizen stakeholders.

The Cedar River Watershed HCP covers many of the costs for the projects recommended in the WRIA 8 plan for the Upper and Lower Cedar River. Staff has successfully leveraged other funding so more can be accomplished. The HCP also provided funding for improving fish passage at the Hiram Chittendon Locks.

1.5 Plan Organization

SPU has organized its water utility into the five business areas described previously. This plan is organized similar to the *2007 Water System Plan*, with the remaining chapters of Part I focused on each of those business areas. Since most of the Major Watersheds business area activities are not required to appear in water system plans, it does not have its own chapter. Each of the chapters in Part I are divided into the following sections:

- A section summarizing SPU's accomplishments since completion of the *2007 Water System Plan*.

- A service level section that describes SPU's performance in meeting the service levels for that business area.

- A description of the facilities that the business area manages, and the practices it follows in operating and maintaining those facilities. This section focuses on changes since the *2007 Water System Plan*.

- A summary of needs, gaps, and issues that face that business area in the next 20 years and beyond, but with a focus on the 2013-2018 planning period.

- 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 in the next 20 years and beyond.

Part II describes the plan for implementing the actions described in Part I, including details on the costs and financing approach for plan implementation.

Appendices to this plan are contained in a separate volume as listed in the Table of Contents and should be considered part of this *2013 Water System Plan.*

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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 supporting hydropower production, and managing floods. Water resource concerns also include forecasting future water demands, and evaluating current supply capacity and the need for future additional supply sources and new water rights. 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 Accomplishments Since 2007 WSP

Since completion of the *2007 Water System Plan*, SPU has accomplished the following activities in the water resources business area:

- Water Conservation: Completed the 2000-2010 Regional 1% Conservation Program, Seattle's additional conservation requirements of the Initiative 63 Settlement Ordinance, and the first 6-Year Water Use Efficiency Goal. More information on past conservation program savings is provided in Section 2.3.3 below.

- North Bend Mitigation Water: Per an agreement signed in 2008, began delivering untreated water from Hobo Springs via Boxley Creek to the city of North Bend to mitigate the use of their municipal water wells on the Snoqualmie River (2009).

- New Wholesale Contracts: Signed new wholesale contracts with the six remaining 1982 wholesale contract holders, the city of Renton, and Cascade Water Alliance. More information is provided in Section 2.3.1 below.

- Cedar Moraine Improvements: Installed a horizontal drainage system in the West Boxley area of Cedar Moraine to partially dewater the moraine embankment, reducing the risk of a groundwater-blowout event flooding downstream properties along Boxley Creek. Completion of the project was a key factor in gaining approval to refill Chester Morse Lake to elevation 1563 feet (2008).

- Tolt Reservoir Temperature Management: Completed an interactive reservoir water quality computer model that enhances water managers' ability to manage the South Fork Tolt Reservoir and installed equipment throughout the entire vertical water column for real-time temperature monitoring and management (2009).

2.2 SERVICE LEVEL PERFORMANCE

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. By meeting these service levels, SPU has high confidence in having adequate water supply to meet all customer demands. Table 2-1 summarizes these service levels.

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

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 (11 mgd annual average) from 2000 to 2010. - Save additional 15 mgd (average annual) from 2011 to 2030. - Meet the Initiative 63 Settlement Ordinance requirements.

Since 2006, SPU has been in compliance with all minimum flow specifications and supplemental flow targets for its Cedar and South Fork Tolt River water supplies. Since 2006, there have been a few downramping events on the Cedar River, in which water levels fell more quickly than prescribed by the Cedar River Watershed Habitat Conservation Plan (HCP). All events have been reported to the Instream Flow Commission and corrective action described and taken. To date, SPU has also met other performance commitments of the Cedar River Watershed HCP and

Muckleshoot Indian Tribe (MIT) Settlement Agreement that do not involve instream flows, including limits on diversions from the Cedar River.

In addition, SPU has achieved its water conservation goals through 2010. Additional information on these achievements is provided in Section 2.3.3. The service level targets for water use efficiency will be updated with the Water Use Efficiency Goal described in Section 2.4.1.1 of this plan.

2.3 EXISTING SYSTEM AND PRACTICES

The total population currently served by SPU and its wholesale customers in King and south Snohomish County is about 1.3 million.

The total population currently served by SPU and its wholesale customers in King and south Snohomish County is about 1.3 million. 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 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 the maintenance activities for the water supply facilities.

2.3.1 Service Area Characteristics

SPU's retail service area includes the City of Seattle and portions of the cities of Shoreline, Lake Forest Park and Burien, as well as portions of unincorporated King County south of the City of Seattle. SPU also provides retail water service to Shorewood Apartments on Mercer Island and SeaTac Airport. The SPU retail service area reflects the proposed annexation of the area known as the Greenbridge Notch (Wind Rose) by Water District 45. Also, the area served in the City of Shoreline may become a wholesale area in 2020 if current efforts by the City of Shoreline are successful in creating a new utility.

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, which, in general, includes the City of Seattle, the suburban areas immediately to the north and south, and similar areas extending east of Lake Washington to slightly beyond North Bend.

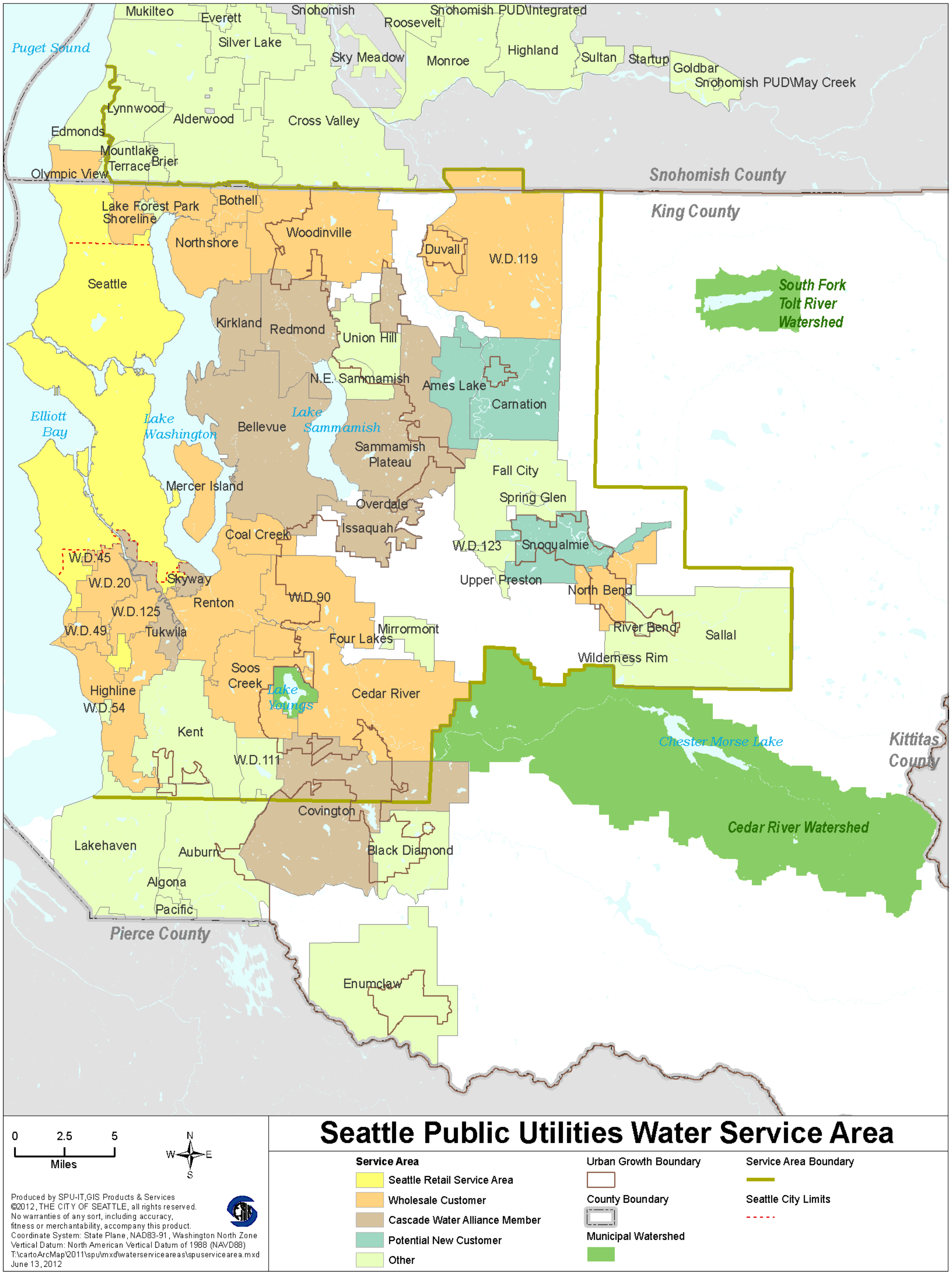


Figure 2-1. SPU's Water Service Area

2.3.1.1 Changes in Demographics

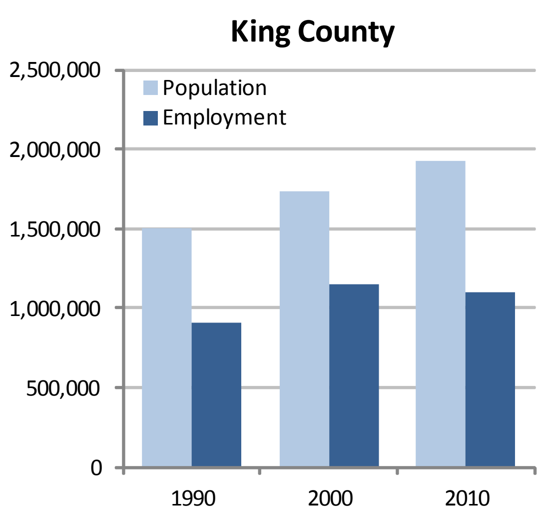
Since 2000, there have been significant changes in demographics that were influenced by the economy. Following the 1990 recession, King County employment grew much faster than population, 27 percent compared to 15 percent, from 1990 to 2000. In the last decade, population grew a little slower at 11 percent, but employment shrank so that 4 percent fewer people were employed in 2010 than in 2000. Table 2-2 and the figures below show the changes in population, households and employment in King County and Seattle.

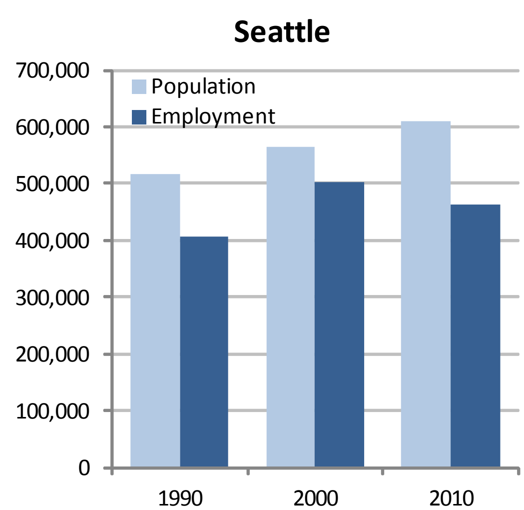
Table 2-2. Demographic Changes

	Population[1]		Households[1]		Employment[2]	
	King County	Seattle	King County	Seattle	King County	Seattle
1990	1,507,319	516,290	615,792	236,715	907,753	407,862
2000	1,737,034	563,374	710,916	258,510	1,149,642	502,835
2010	1,931,249	608,660	789,232	283,510	1,099,639	462,180
Change						
1990-2000	229,715	47,084	95,124	21,795	241,889	94,973
2000-2010	194,215	45,286	78,316	25,000	-50,003	-40,655
% Change						
1990-2000	15.2%	9.1%	15.4%	9.2%	26.6%	23.3%
2000-2010	11.2%	8.0%	11.0%	9.7%	-4.3%	-8.1%
Annual %						
1990-2000	1.4%	0.9%	1.4%	0.9%	2.4%	2.1%
2000-2010	1.1%	0.8%	1.1%	0.9%	-0.4%	-0.8%

[1] U.S. Census: 1990, 2000 and 2010

[2] Puget Sound Regional Council covered employment estimates





2.3.1.2 Retail Customers

SPU delivers water directly to a population in its retail service area of more than 664,000 through more than 188,000 service connections, approximately 36,000 more people than indicated in the *2007 Water System Plan*. This increase has resulted from increased population density from development of vacant property and redevelopment of property to higher densities.

2.3.1.3 Wholesale Customers

SPU's wholesale customers, excluding North Bend, provide SPU water to a resident population of about 629,000. Current Seattle wholesale customers, listed in Table 2-3, include 19 municipalities and special purpose districts, plus Cascade Water Alliance.

Table 2-3. SPU Wholesale Water Customers

Full Requirements Contract Holders	
• Bothell, City of	• Water District No. 20
• Cedar River Water and Sewer District	• Water District No. 45
• Coal Creek Utility District	• Water District No. 49
• Duvall, City of	• Water District No.119
• Mercer Island, City of	• Water District No.125
• Shoreline Water District	• Woodinville Water District
• Soos Creek Water and Sewer District	
Partial Requirements Contract Holders	
• Highline Water District	• Renton, City of
• Olympic View Water and Sewer District	• Water District No. 90
Block Contract Holders	
• Cascade Water Alliance (Cascade)[1]	• Northshore Utility District
Mitigation Water	
• North Bend, City of[2]	

[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 mitigation water from Boxley Creek that is not treated.

In addition to the above, the City of Edmonds and Lake Forest Park Water District have emergency intertie contracts with SPU covering all types of emergencies. SPU also has an emergency water sales agreement with the City of Renton to provide water to the Seattle Regional Water Supply System from Renton.

Since the last of the 1982 contract holders signed new contracts in 2011, SPU now provides regular municipal water service to its wholesale customers under three contract types:

- Full Requirements Contracts. Thirteen of SPU's wholesale customers, as shown in Table 2-3, now receive all of their water supply under full-requirements contracts. These 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.

- Partial Requirements Contracts. As shown in Table 2-3, four of SPU's wholesale customers purchase water from SPU under a partial requirements contract. These utilities have their own sources of supply with which they meet a portion of their demand and depend 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 (Northshore).

    - 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. A contract amendment in 2008 provides for supplemental blocks of water of 3 mgd from 2009 through 2017 and 5 mgd from 2018 through 2023 that are in addition to the blocks specified in the first contract. Cascade chose to not participate on the Operating Board and the regional conservation program.

    - 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 into the future. Northshore provides water directly to its retail customers and participates on the Operating Board and in the regional conservation program.

2.3.2 Water Demand

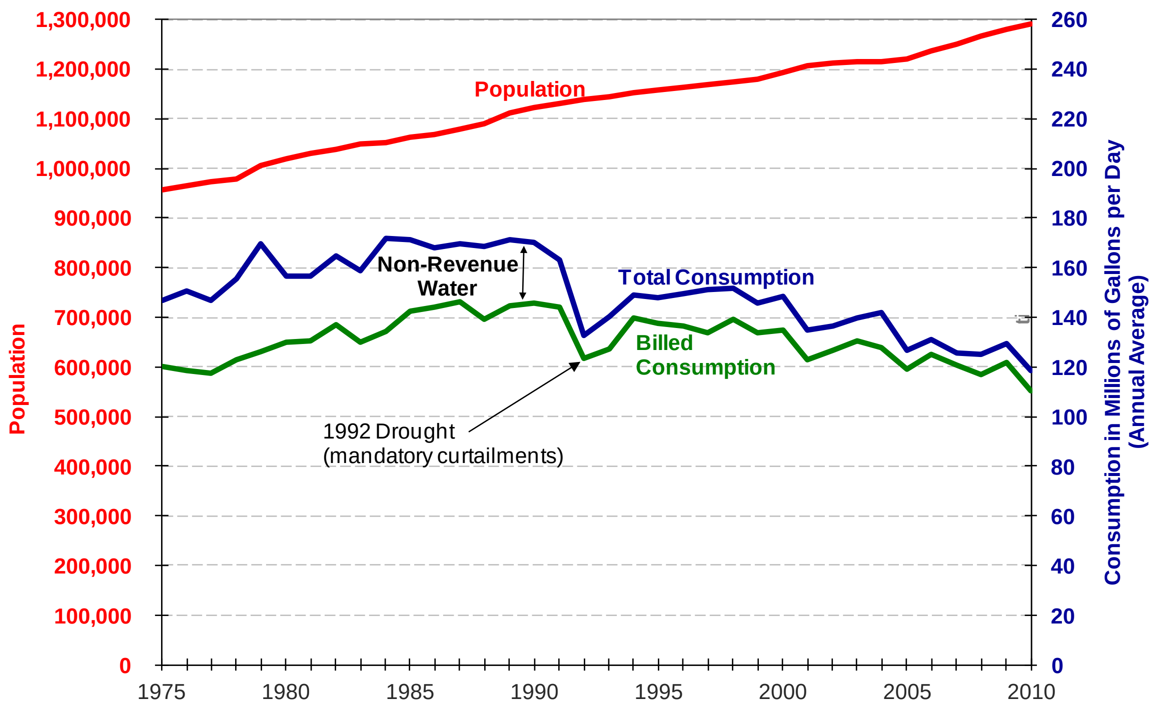
For most of Seattle's history, water consumption increased along with its population. However, that link was broken around 1990 when consumption reached its highest level. Since then, water consumption has steadily declined despite continued population growth. By 2010, consumption was lower than it had been since 1957 when the regional service area was smaller.

Are people using less water?

Yes! Today, people in SPU's regional water supply system use 30% less water than they did In 1990. Total water consumption is now lower than it was in 1957, despite population growth.

2.3.2.1 Historical Water Consumption

Figure 2-2 displays Seattle system water consumption and service population since 1975. While population has steadily risen since 1975, water demand leveled off during the 1980's before dropping off sharply in 1992 due to a severe drought and mandatory curtailment measures. Since then, the combined effects of higher water and sewer rates[1], new federal and state plumbing codes, utility conservation programs, and improved system operations kept both billed and total consumption significantly below pre-1992 drought levels. Also, water consumption in recent years has also been impacted by the ongoing economic recession. Between 1990 and 2010, consumption has decreased about 30 percent (50 mgd) while population increased by 15 percent.



Note: Population is adjusted to reflect the proportion of resident service area population actually using SPU water (i.e., excludes those that receive water from other sources).

Figure 2-2. Population Growth and Water Consumption from SPU Sources

[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.

One benefit of the lower demand is a reduced need for treated water storage and their associated costs and water quality impacts.

Peak water demand has fallen even more than annual average demand since the 1980's when hot summer weather could produce peak day consumption of over 330 mgd. In the last ten years however, peak day consumption has stayed below 250 mgd even on the hottest days. Recent years with cool summers, peak day consumption has been below 200 mgd. Peak month and peak week consumption have also been trending downwards over the past twenty plus years, though not as steeply as peak day consumption.

2.3.2.2 Non-Revenue Water

SPU's system non-revenue water is calculated by subtracting total metered water sales, both retail and wholesale, from total water production. Distribution System Leakage, as reported to the state, is a component of non-revenue water. Since the *2007 Water System Plan*, the amount of non-revenue water has declined due to reduced use of water for system operations. As the remaining open reservoirs have been covered and buried, overflowing for water quality reasons has been substantially reduced, as has the need to empty the reservoirs for cleaning. Table 2-4 reflects SPU's best estimates of the components of non-revenue water for 2010.

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

Total Non-Revenue Water	**8.0 mgd**
System Operations	**0.3 mgd**
Reservoir Overflowing	<0.1 mgd
Reservoir Draining/Cleaning	0.2 mgd
Water Main Flushing	<0.1 mgd
Public Uses	**0.3 mgd**
Sewer flushing, fire fighting, etc.	0.3 mgd
System Losses	**7.4 mgd**
Measured Losses (Reservoir Leaks/ Net Evaporation)	0.3 mgd
Unmeasured Losses (Pipeline Leaks and Other)	3.7 mgd
Meter Inaccuracies[a]	3.4 mgd

Note: All the above categories except meter inaccuracies were estimated by water planning 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.

2.3.3 Water Conservation Programs

Passive Savings are reductions in water use that occur as customers, without SPU intervention, purchase new plumbing fixtures and water-using appliances that meet, or in many cases exceed federal and state codes.

SPU's water conservation strategy includes a comprehensive regional program for Seattle and participating wholesale customers, as well as a targeted effort for Seattle's low-income residents. Savings also come from water rates designed to promote conservation, passive savings, and system efficiencies.

2.3.3.1 Regional Conservation 2000-2010

In 1999, SPU took on an ambitious goal: keep water demand from increasing over the next ten years, despite projected regional population and economic growth. At the time, Seattle was one of the few large cities in the country attempting to manage expected growth in water demand through conservation.

A key component of SPU's water conservation approach was achieved by its Saving Water Partnership – a collaborative program run by Seattle and 17 of SPU's wholesale customers[1]. The program emphasized long-term water use efficiency without customer sacrifice. The regional program set a savings target of about 1 mgd per year, or a cumulative average annual total savings of 11 mgd.

Conservation measures promoted by the program eliminated unnecessary, wasteful use of water while customers and the community continued to enjoy high-quality drinking water.

With support of residential, commercial and institutional customers, the Saving Water Partnership achieved a cumulative savings total of 9.6 mgd from the year 2000 through 2010, at a cost to the participating utilities of $35 million. Highlights of the measures implemented during the program are shown in Table 2-5. The *Saving Water Partnership 2010 Annual Report and Ten Year Program Review* provides additional detail on the program's accomplishments and is available on the Saving Water Partnership web-site.[2]

[1] The City of Renton joined the Saving Water Partnership in 2011, bringing the total number of participating wholesale customers to 18. As of January 2012, Saving Water Partnership members include SPU along with Northshore Utility District, and all Full and Partial Requirements Contract utilities: Cedar River Water & Sewer District, City of Bothell, City of Duvall, City of Mercer Island, City of Renton, Coal Creek Utility District, Highline W.D., Olympic View Water & Sewer District, Shoreline W.D., Soos Creek Water & Sewer District, W.D. 20, W.D. 45, W.D. 49, W.D. 90, W.D. 119, W.D. 125, and Woodinville W.D.

[2] http://www.savingwater.org/docs/2010_Annual_Report.pdf

Table 2-5. Summary of Regional 1% Program Accomplishments 2000-2010

Measures Implemented	Strategies Implemented
RESIDENTIAL INDOOR	
• Replace washing machines • Replace toilets, showerheads & faucets (multifamily) • Fix leaks (toilets) • Change behaviors (faucet use, shower time, full loads)	• 180,392 showerheads distributed to single-family residents • 78,770 washing machine rebates and 1,073 multi-family coin-op rebates • 32,838 multifamily and 5,773 single family toilet rebates • 36,693 showerheads and aerators distributed to multifamily properties • Behavior messaging • Collaboration with energy utilities • Program recruiting through retailers, radio, TV and print ads, ads in property manager trade publications, website • Promotion of Flush Star and Water Sense toilet performance
RESIDENTIAL LANDSCAPE	
• Improve irrigation system performance • Change landscape watering behaviors • Encourage practices that affect watering (e.g. mulch, soil prep and plant selection)	• 1,015 Irrigation system efficiency rebates • Right Plant, Right Place promotion via retailer partnerships (nurseries, home and garden centers) • Savvy Gardener e-newsletter and classes – 3,451 subscribers; 4,149 class attendees • The Garden Hotline – 134,152 questions answered • Natural Lawn & Garden Guides (how-to materials) – 590,440 distributed • Training for irrigation professionals • Develop irrigation technology performance testing through Irrigation Association Smart Water Application Technologies Initiative • Online weather data, watering index, water budgeting and irrigation scheduling tools
COMMERCIAL PROCESS/DOMESTIC	
• Upgrade toilets and other domestic water use fixtures • Upgrade industrial and commercial water-using equipment • Improve building cooling performance • Upgrade efficiency of specific water consuming medical and lab equipment • Outreach to ethnic businesses	• Financial incentives (723 custom projects & standard rebates) • Targeted promotion through vendors, trade groups, agencies with focus on Mexican and Korean businesses • Restaurant targeting – Commercial Kitchen Equipment Partnership with multiple energy and water utilities • Outreach to business groups through Resource Venture (www.resourceventure.org) • Technical assistance, assessments, workshops • End-use metering to build cost-effective conservation recommendations
COMMERCIAL LANDSCAPE	
• Upgrade irrigation equipment (controllers, rain sensors, drip) • Improve scheduling and maintenance • Train irrigation contractors and installers	• Targeted outreach to large commercial customers • Site-specific recommendations and technical assistance • Financial incentives (custom projects and set rebates) – 375 businesses and institutions • Targeted recruiting and promotion to large commercial customers • Market transformation by establishing and building vendor and contractor relationships • Online weather data, watering index, water budgeting and irrigation scheduling tools • Training for irrigation professionals – 500 attendees
YOUTH EDUCATION	
• Build conservation awareness and residential measures	• Educator resources – teacher trainings and materials online • Classroom and take-home materials – 43,660 conservation kits distributed; 12,900 water system posters distributed; 9,000 activity books distributed • Web-based interactive activities – 44,911 Water Buster game players • Support of water festivals and events
OVERALL MESSAGING	
• Conservation awareness supporting recruitment of residential and commercial customers	• Market EPAWaterSense labeled products • Promote regional website: www.savingwater.org • Water conservation hotline: 684-SAVE • Collaboration with Partnership for Water Conservation • Festivals, utility open house events • Radio, TV, public transit, and print advertising

After ten years, the overall goal of keeping demand flat was not only achieved, but exceeded. The programmatic savings were complimented by additional savings from standards, codes, rates, and system operation changes. Average annual demand was lower in 2010 than in 2000. Figure 2-3 illustrates the components that have contributed to a greater than 30 mgd reduction in water use since 2000.

While population has steadily increased, water consumption has decreased by over 30 mgd since 2000.

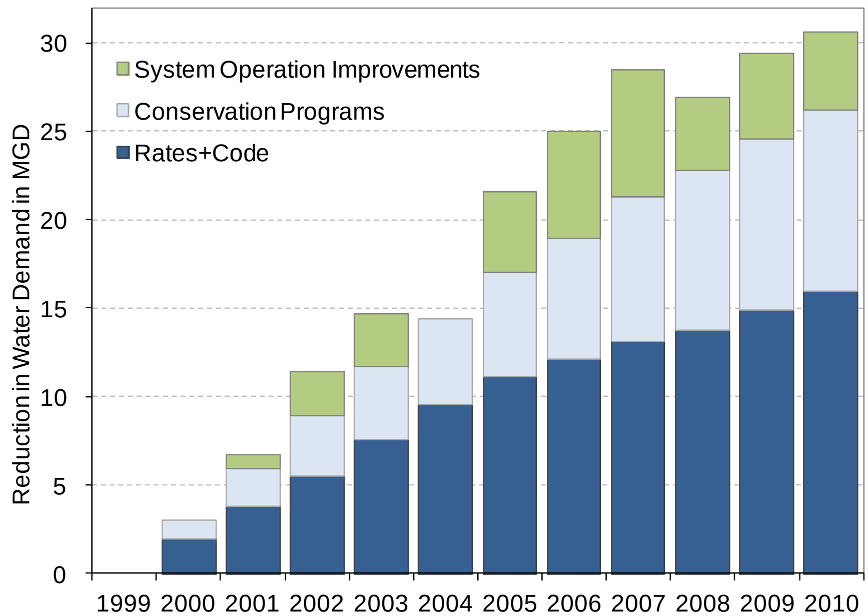


Figure 2-3. Cumulative Water Savings from Conservation, in Average Annual mgd, 1999-2010

2.3.3.2 Seattle-Only Conservation 2003-2010

In addition to the regional program, SPU has implemented a water conservation program exclusively for low-income customers in Seattle. The City of Seattle adopted the I-63 Settlement Ordinance in 2001 (Ordinance 120532), which committed the City to pursue conservation beyond the Regional Program in the SPU direct service area and to focus on low-income housing conservation assistance by establishing the “Everyone Can Conserve Program.” From 2002 through 2010, the program retrofitted over 20,000 income-qualified housing units with water conservation fixtures and equipment. A similar but modified Program continues post-2010 as part of the City’s efforts to help low-income customers manage their water bills.

Ordinance 120532 directed SPU to provide 3 mgd of water savings in the Seattle retail service area by 2010 through the low-income conservation program, rate structures that provide conservation incentives, increased system efficiencies resulting from the accelerated in-town reservoir replacement program, and other cost-effective measures. SPU has met these requirements.

2.3.3.3 Water Use Efficiency Goal and Program 2007-2012

As part of the process to comply with the WDOH Water Use Efficiency Rule, the Saving Water Partnership utilities updated regional policy objectives for water conservation and set a six-year regional goal. These goals were described in SPU's *2007 Water System Plan*. For the Saving Water Partnership, the 2007-2012 regional water conservation objectives were to provide:

- Low-cost insurance for meeting potential future challenges from climate change;
- Efficient management of water resources; and
- Assistance to customers with managing their bills.

For its 2007-2012 Water Use Efficiency Goal, the Saving Water Partnership adopted cumulative average annual regional programmatic water saving targets of 11 million gallons per day from 2000 through 2010 and 15 mgd of both price and programmatic savings from 2011 through 2030. The six-year portion of these two regional targets, from 2007 through 2012, is estimated to total 5.98 mgd. As with earlier programs, the range of services for customers remains a mix of education as well as financial rebates for water saving equipment.

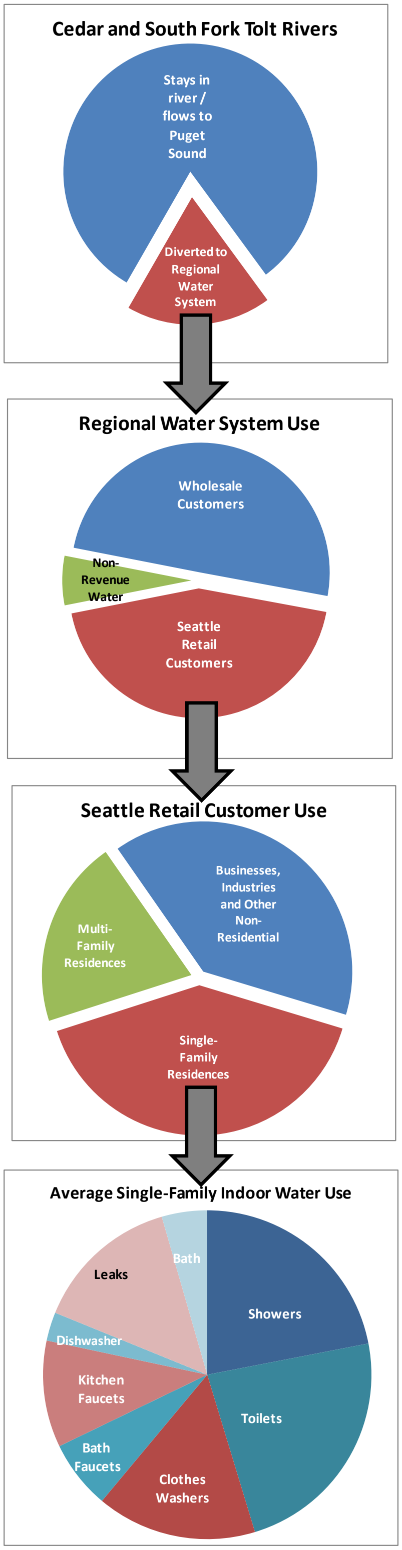
Note that in addition to the regional goal, SPU's 2007-2012 Water Use Efficiency Goal includes additional water savings in its direct service area. Additional water savings of 2.57 mgd are estimated to be achieved from implementation of the requirements of Seattle Ordinance 120532.

SPU's Water Use Efficiency annual reports are available on the WDOH web-site and are reported to SPU's customers in the annual Drinking Water Quality Report.

2.3.4 Existing Water Supply

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.

Where is all of the water from the Cedar and Tolt used?



2.3.4.1 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. Seattle's two well fields are available to provide drought and emergency supply. Additional information about each supply source is included below. The few changes that have occurred since the *2007 Water System Plan* are noted.

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 Masonry Dam. The reservoir stores 13 billion gallons (40,000 acre-feet) between elevations 1563 and 1538 feet.

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 and discharge dike during low reservoir conditions (below approximately elevation 1538 feet). Use of the pumping plants requires rental and installation of mobile diesel generators, installation of flashboards at the Discharge Dike, and other set up activities which necessitate a lead-time of up to two months prior to actually needing to pump.

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 Water Treatment Facility.

Some of the Cedar River source water is lost from 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 a portion returns to the river in the summer, when it provides a water supply benefit in the critical fall season, before the fall rains return. About 75 to 80 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. Some of this seepage is discharged through Hobo Springs. In 2009, piping was installed to divert water from Hobo Springs to Boxley Creek for the city of North Bend to mitigate use of their wells on the Snoqualmie River. The amount of water provided was 0.09 mgd in 2009 and 0.05 mgd in 2010.

The Cedar Moraine Safety Study identified that the West Boxley area of the Cedar Moraine could result in a groundwater burst failure under seismic conditions when steady-state groundwater levels reach those associated with Masonry Pool elevation 1555 feet and above. The flood resulting from the groundwater burst failure could impact people downstream. The annual probability of failure for the seismically-induced groundwater burst was estimated at 1 chance in 2,400. This annual probability of failure does not meet Department of Ecology Dam Safety Office requirements of a less than one in 10,000 year probability of failure.

In order to meet Ecology requirements, SPU constructed a subsurface drainage system into the face of the moraine hillside embankment. The purpose of the drainage system is to capture groundwater prior to reaching the slope face, thereby reducing the potential for a groundwater burst flow event. An additional result of the installation of the drains is that SPU received Ecology authorization to officially have a normal permanent refill level of elevation 1563 feet in Chester Morse Lake.

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 Water Treatment Facility.

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 drought 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.

2.3.4.2 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, as indicated by the Water Rights Evaluation contained in the appendices. One change in status of these water rights is that the term permit for the Cedar River (Morse Lake) Pumping Plant has expired. Since SPU's Cedar River claim includes the use of this water, it is not necessary to renew the permit.

Also, SPU received a water right permit in 2007 to capture and put to use rainwater that falls on rooftops of structures in the combined and partially separated sewer basins of the City of Seattle. This permit includes a map for areas covered. Under this permit, Seattle would authorize, with conditions, individuals, businesses and other entities within the mapped area to collect and use rainwater. After receiving the permit, Ecology released in 2009 Interpretative Statement / Policy 1017 regarding collection of rainwater for beneficial use to clarify that a water right is not required for on-site storage and use of rooftop-collected rainwater.

SPU is requesting its water rights place of use be changed to include small portions of southern Snohomish County.

Through the *2007 Water System Plan*, SPU changed its place of use for the Cedar River and Lake Youngs claims to be the service area described in that plan as allowed by the 2003 Municipal Water Law (WAC 246-290-107). Through this water system plan and the State review process, SPU is modifying its service area so as to clarify that the service area includes small areas in Snohomish County currently served by Northshore Utility District, the City of Woodinville, and the City of Bothell, as well as potential service area additions proposed by Water District 119. These areas are shown in Figure 2-1 and are based on the following:

- Northshore Utility District, Water System Comprehensive Plan, December 2006, retail service area, including retail service area by Agreement, as shown in Figure 3-1 of that document.

- Woodinville Water District, 2008 Comprehensive Water System Plan, water service area, including interim service, as shown in Figure 2-1 of that document.

- City of Bothell, Water System Plan, February 2011, water system retail service area, as shown in Figure 1-2 of that document.

- Proposed service area additions as indicated by Water District 119, which consist of Snohomish County Sections 31, 32, 33, and 34 of Township 27 North, Range 7 East, east of Highway 203. This area includes properties for which Water District 119 has received requests for service in the recent past due to poor groundwater conditions and the lack of other nearby water purveyors. Any new service to this area is subject to approval by SPU, Snohomish County, King County, WDOH and other jurisdictions.

An evaluation of specific Seattle water right claims, permits, and applications as called for in WDOH planning guidelines is included as an appendix. Forecasts indicate that Seattle does not need to apply for any new water rights within the 20-year planning horizon.

2.3.4.3 Firm Yield and Supply Reliability

Firm yield of SPU's water supply has been updated to 172 mgd, an increase of 1 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, treatment and transmission capacity, and other system constraints, including diversion limits for the Cedar River as set forth in the 2006 Agreement with the Muckleshoot Indian Tribe. Firm yield is expressed as an average annual delivery rate in mgd from all sources operating 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 81 years of reconstructed historic flow records that takes into account past weather and hydrologic variability 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 firm yield calculation was updated in 2011 to include inflow dataset through 2009 and to represent current operating conditions, namely the use of the current spring refill target of elevation 1563 feet for Chester

Morse Lake and the use of a revised monthly demand distribution based upon the actual demand of 2005 through 2009. The result was that the firm yield increased by one mgd. The combined firm yield of all SPU supplies is currently estimated to be 172 mgd.

2.3.5 Operations

The surface water supply facilities on the South Fork Tolt and Cedar Rivers are operated primarily for water supply and protection of 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. Should a drought or other water supply emergency occur, SPU would activate the Water Shortage Contingency Plan (WSCP) contained in the *2007 Water System Plan*. Since the *2007 Water System Plan*, the WSCP has not been activated, and the only time that these wells were used was in 2008. Groundwater elevations during this period are provided in the appendices. Water resource management and operations have changed since the *2007 Water System Plan.* The changes include the following and are described more fully below:

- Installation of the moraine drains resulting in Chester Morse Lake refill elevation of 1563 feet being authorized and changes to seepage from Masonry Pool.

- Operations intended to maintain higher pool levels to better avoid the use of the floating pumps in Chester Morse Lake.

- Management of outlet water temperatures at South Tolt Reservoir in support of South Fork Tolt River fisheries.

- Adjustments to the instream flow requirements for the Cedar River due to the change in hydrology when Walsh Lake Ditch was disconnected and became a tributary to flows above Landsburg on the Cedar River.

2.3.5.1 Chester Morse Lake Refill and 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. The losses are directly proportional to Masonry Pool Reservoir level.

The authorization to allow refill to an elevation of 1563 feet does result in more storage but also leads to increased loss to the moraine. With installation of the moraine drains, some increase in loss to the Snoqualmie Basin has been observed, but the magnitude and timing of this increase is still under evaluation. However, past studies have shown that the seepage 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. As noted in the *2007 Water System Plan*, analysis conducted by SPU found that if seepage from Masonry Pool were completely eliminated, an estimated 24 mgd of firm yield would be lost.

Installation of the drains in Cedar Moraine has allowed refill of Chester Morse Lake to elevation 1563 feet.

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.

2.3.5.2 Operational Changes to Avoid Use of Floating Pumps

Surveys in 2002 and in subsequent years have revealed that a portion of the Outlet Channel between Chester Morse Lake and Masonry Pool had filled in with sediment resulting in a diminished capacity to convey a sufficient volume of water to meet water supply and instream flow objectives. The channel was dredged in 2002 and 2010, which partially restored the flow capacity. In addition, the Discharge Dike crest elevation was raised in 2002 to 1538 feet, and effectively moved up the minimum elevation at which gravity flow can be maintained and established a new elevation below which pumping is required. This has led to a need to activate the pumps sooner, and consequently more frequently, than what would have occurred in the past. In addition, the existing floating barge system has numerous mechanical and electrical components that are in need of replacement.

Water resource operations in recent years have taken into consideration the condition of the existing floating pumps and channel. The current operational goal is, to the maximum extent practicable, reduce the likelihood that the floating barge system would need to be mobilized during the fall or winter by keeping as much water as practical in Chester Morse Lake. To meet this objective, the river and reservoir system is managed to maximize refill during the spring, maintain the level as long as possible, avoid releases when possible during the summer and early fall, reduce seepage losses in the summer and fall, use more Tolt water, optimize use of Lake Youngs, and use the wells if necessary. While the Morse Lake Pump Plant Project, described below, will improve the floating pump system, SPU intends to continue operating the reservoir in this same manner so as to reduce the likelihood of needing to pump.

2.3.5.3 Temperature Management at South Fork Tolt Reservoir

SPU has been successful at meeting water temperature objectives in the South Fork Tolt River.

SPU uses existing reservoir intake gates to release water from different water depths in the South Fork Tolt Reservoir to provide beneficial water temperatures for instream resources in the river downstream of the reservoir. Specific objectives of this program are to maintain water temperatures throughout the lower South Fork Tolt River within Washington Department of Ecology Standards and at levels that are similar in pattern to temperatures in the unregulated North Fork Tolt River. Since implementation of this program began in 2004, SPU has been successful at meeting these objectives without compromising water supply.

2.3.5.4 Walsh Lake Ditch Disconnect

From 1904 to about 1947, the town of Taylor, Washington, was a large mining and manufacturing community in the western Cedar River Municipal Watershed. In the 1930's, the City of Seattle constructed the Walsh Lake Diversion Ditch (Ditch) to divert the water contaminated by this community. The water was diverted just above the natural confluence with Rock Creek, a tributary of the Cedar River in the Municipal Watershed, and conveyed 1.7 miles to a discharge point on the Cedar River downstream of the Landsburg Diversion Dam (the diversion point for Seattle's Cedar River municipal water supply). Following abandonment and decommissioning of the Taylor townsite in 1947, water quality impairment in the 4.3 sq mi Walsh Lake Basin naturally recovered, making the Ditch obsolete. The Ditch—contained by a constructed earthen levee—is located in a steep ravine above Rock Creek. During a January 2009 storm event, a 300-foot section of the Ditch catastrophically failed, resulting in the natural reconnection of the Walsh Lake sub-basin to its historic tributary flow into Rock Creek—effectively disconnecting and largely dewatering the downstream section of the Ditch.

To account for this change in hydrology with regards to Seattle's water supply and instream flow management, SPU in consultation with the Cedar River Instream Flow Commission adjusted the instream flow requirements in the river by the mean weekly flow contribution from the Ditch (annual mean of 8.6 cfs). In 2012, SPU plans to improve the now-reconnected confluence of Rock Creek and Walsh Lake Ditch, to stabilize the area, and to make long term improvements to stream habitat at the confluence. This work includes the removal of the former concrete diversion weir structure, and breaching of the remnant section of the earthen Ditch levee to stabilize the hillslopes in the area adjacent to the former Ditch.

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 Federal Energy Regulatory Commission (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. A SAMP for Lake Youngs has been completed and one for the Tolt is expected to be completed in 2012. These SAMPs will analyze how SPU should maintain and repair the dams and make recommendations as to any renewals of the existing dams or their components. They will also include recommendations regarding elements such as the mechanical and electrical equipment associated with the dams, including the dam failure warning systems. The key result from the Lake Youngs SAMP is the recommendation to begin analysis of the eastern Cascades Dam for ways to reduce impacts of a seismic induced failure on water quality (see Section 2.4.2.5 for more information).

2.4 Needs, Gaps, and Issues

Needs, gaps, and issues facing the Water Resources business area include appropriately planning for water supply in the face of uncertainty and potential climate change impacts and improving water supply infrastructure and operational practices to make the best use of existing supplies. The Water Use Efficiency Goal and program for the 2013-2018 time period is also described, along with an updated water demand forecast. Each of these specific issues is discussed in the following section, along with how SPU plans to address them.

2.4.1 Future Water Demand and Supply

There are uncertainties affecting both future water demand and future water supply. 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 the condition of water supply infrastructure, new operating constraints, climate, the feasibility of developing new supplies as needed, and other factors, such as legal and regulatory issues. SPU has developed water demand forecasts and analyzed future water supply using frameworks that incorporate these relative uncertainties. The results of SPU's analyses are described in the following sections.

2.4.1.1 Water Use Efficiency Goal and Program 2013-2018

For over twenty years, SPU and its wholesale utility customers have successfully designed and delivered water conservation programs for residents, businesses and institutions throughout the regional service area. Conservation has proven to be an effective and flexible strategy. In the early years, conservation programs helped educate customers about the efficient use of water and successfully built an ethic of stewardship. Having an established program was a key response strategy during droughts when voluntary and mandatory customer water curtailment was needed. Later, conservation programs helped to decrease per capita water use when the need for a new source of supply was forecast.

Experience has demonstrated the value of periodically assessing the reasons for and role of customer-based conservation programs in water system planning -- to ensure that the program emphasis supports utility needs, reflects customer preferences, and recognizes changing regulatory and market factors that affect water use efficiency.

As of January 2012, in the Seattle water system, SPU and 18 of its wholesale utility customers operate regional conservation programs collaboratively as the Saving Water Partnership[1]. Utility members set and oversee conservation goals, objectives, and program intensity through the Operating Board. Staff from the utilities comprise the Water Conservation Technical Forum, which is tasked with designing programs within parameters defined by the Operating Board. In SPU's retail area, a customer-based Water

[1] For Saving Water Partnership member listing and website, and regional conservation goals, programs, and accomplishments through 2012, see Sections 2.3.3.1 and 2.3.3.3.

System Advisory Committee provides additional customer input and feedback on conservation goals, objectives, and programs.

To scope and scale regional conservation initiatives for the 6-year planning timeframe required by the Washington State Water Use Efficiency (WUE) Rule, the Saving Water Partnership reviewed the current water demand forecast, which is described in the next section, prior to adopting a Water Use Efficiency Goal and Program. The demand forecast indicates that a new source of supply is not needed before 2060 despite continued growth in regional population. This is, in part, due to increased attribution of passive conservation savings as a factor in reducing per capita demand.

Conservation prepares the region for potential water supply challenges, helps customers use water wisely, and preserves the ethic of stewarding natural resources.

The Saving Water Partnership recognizes that the utilities and their customers benefit from a regional conservation program that ensures staff expertise and strong industry partnerships are available to meet a variety of water system needs. This "conservation infrastructure" prepares the region for potential water supply challenges, helps customers use water wisely, and preserves the ethic of stewarding natural resources.

As a statement of objectives for its regional conservation efforts from 2013-2018, the Saving Water Partnership will:

- Ensure core capacity is available to deliver conservation programs that prepare the utility to be resilient for curtailment events and future supply challenges from climate change, as well as help customers use water wisely;

- Preserve customers' ethic of conservation as one element of stewarding our water resources and the environment; and

- Meet regulatory and contractual requirements.

The Saving Water Partnership utilities set a regional combined conservation goal that reflects a reduction in per capita water demand – for residents, businesses, and institutions throughout the regional service area – and holds total water use below a specified level despite population growth being forecasted to increase by 3.9 percent over the six-year period. The goal is formally adopted by each utility's governing body and is reported on annually by each utility. The goal for the Saving Water Partnership service area captures the cumulative effect of all demand-side conservation indicated in the water demand forecast including water savings from utility funded customer-based programs, price-induced conservation from customer response to water and sewer rate increases, and passive savings.

The Saving Water Partnership's regional 2013-2018 Water Use Efficiency Goal is to:

Reduce per capita water use from current levels so that total average annual retail water use of members of the Saving Water Partnership is less than 105 mgd from 2013 through 2018 despite forecasted population growth.

The metric for determining success of the Water Use Efficiency Program measures reductions in metered retail water consumption in the Saving Water Partnership members' service areas, regardless of whether the water is supplied by SPU or a member's own source of supply.

The Saving Water Partnership defined the regional utility-funded customer-based program in its 2013-2018 Water Use Efficiency Program to support its objectives and 6-year goal. The customer-based conservation program is one component of demand management included in the regional 2013-2018 Water Use Efficiency Goal. Selection of measures for the customer-based conservation program is based on an understanding of national appliance and fixture codes, estimates of sales in the market that exceed code, reviews of regional conservation potential analysis and Saving Water Partnership program impact evaluations, market research with utility customers to assess program acceptance and effectiveness, and opportunities for partnerships to leverage water utility funds. Considerations also include ensuring balanced service across customer classes, providing conservation services across utility member service areas, and opportunities to reach traditionally under-served populations. Because the current demand forecast does not indicate that a new source of water supply is needed until sometime after 2060, a set level of avoided water supply cost with which to compare conservation measures is not available.

The 2013-2018 Water Use Efficiency Program renews emphasis on consumer and youth education along with a priority to benchmark customer attitudes about water conservation. It also includes educational campaigns for leak prevention and water use in the landscape. Additionally, the program continues to share costs with customers who retrofit old water-using equipment with new equipment that is more efficient than national and State appliance and fixture codes. Conservation measures for the 2013-2018 Water Use Efficiency Program are summarized in Table 2-6.

Table 2-6. Summary of Saving Water Partnership 2013-2018 Water Use Efficiency Program

General Activities	Specific Measures
CUSTOMER BEHAVIOR CHANGE	
• Community events, schools support, customer education	• Schools outreach • Festivals, shows and fairs • Customer technical assistance • Regional phone hotline: 684-SAVE • Tips on Tap articles for utility newsletters • Media promotion and advertising • Customer mailings • Regional web site: www.savingwater.org • Partnerships with vendors, trade groups, agencies and energy utilities • Awards and recognition • Education on water pricing and conservation rates • Equitable customer access to conservation messages and services
• Leaks and indoor water use education	• Find and fix leaks instructional videos and information on web and in print • Leak detection dye strips distributed via direct mailings
• Landscape water use education	• Landscape classes for residential gardeners • Irrigation scheduling and maintenance • Expert one-on-one advice through the Garden Hotline • Natural Lawn & Garden Guides (how-to materials) and other brochures • Online weather data, watering index, water budgeting and irrigation scheduling tools • Irrigation training in multiple languages for professionals • Smart Water Application Technologies testing
• Benchmarking customer behavior	• Customer research including identification of traditionally underserved populations and program design options to meet their needs • Technical studies and end-use metering • Conservation measure evaluation
WATER EFFICIENT EQUIPMENT UPGRADES	
• Residential indoor water use	• Single-family toilet rebates • Multi-family toilet rebates
• Residential and Commercial irrigation systems	• Weather-based irrigation controllers • Pressure regulating and efficient spray heads • Drip irrigation and micro sprays • Seasonal adjust (percentage) controllers • Irrigation system leak monitoring alarms
• Businesses and institutions	• Technical assessments and outreach • End use metering and monitoring • Plumbing fixture rebates for toilets, urinals, showerheads, aerators, etc. • Cooling and process water rebates • Food service equipment rebates • Medical and lab equipment rebates • Laundry equipment rebates • Steam condensate equipment rebates • Partnerships with energy utilities • Evaluation of reclaimed water opportunities

The Saving Water Partnership estimates the average savings from the 2013-2018 Water Use Efficiency Program will be 0.3 to 0.4 mgd of annual savings at an estimated annual utility cost of $2,150,000 (2011 dollars). The estimated annual mgd savings from the Water Use Efficiency Program are one component of the 6-year regional Water Use Efficiency Goal, which captures all sources of demand reductions**.**

2.4.1.2 Water Demand Forecast

The new water demand forecast includes passive conservation savings and is lower than the last forecast – and still indicates that no new supply needed before 2060.

Long-term water demand forecasting is critical for water system planning. SPU has updated and improved the Demand Forecast Model developed for the *2007 Water System Plan*. This new model 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. The model incorporates estimates of the impacts of passive savings on the water use factors over time, as described below. More information on the model, data sources and assumptions are provided in an appendix.

SPU's official water demand forecast is presented in Figure 2-4, and the various components that add up to the total demand forecast are shown in Figure 2-5. The demand forecast is considerably lower than the *2007 Water System Plan* forecast, particularly in the outer years, and remains considerably below SPU's current firm yield of 172 mgd until well after 2060. Total demand is forecast to remain relatively flat through 2023, at which point the Cascade block begins to step down. Over the two decades that follow, water demand is forecast to decline as the periodic reductions in Cascade's block more than offset what would otherwise be a modest amount of growth in demand. Once the Cascade block has been reduced to its minimum level in 2045, water demand is forecast to begin rising again, finally reaching 132 mgd – back to current levels – 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, this forecast indicates that no new source of supply is needed before 2060.

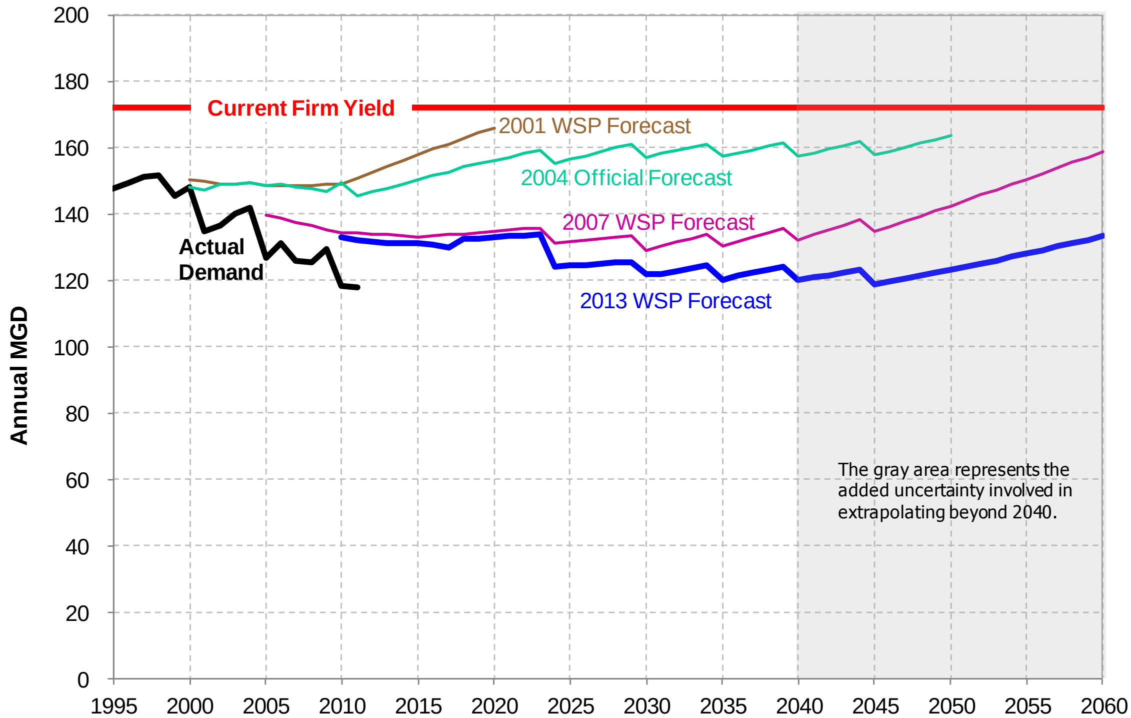


Figure 2-4. SPU's Official Water Demand Forecast

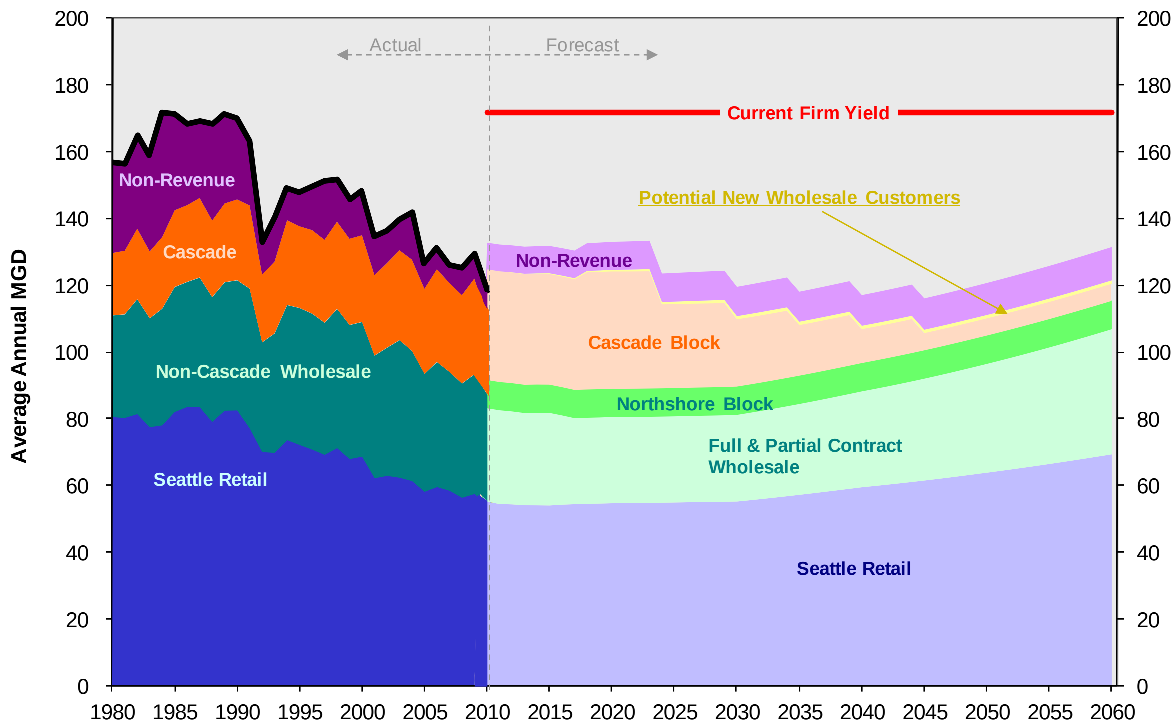


Figure 2-5. Components of Actual and Forecasted Demand

Note: Forecast demand is higher than actual demand in 2010 because the forecast includes all block contract amounts, whereas the actual demand by Cascade and Northshore has been less than their block contract amounts. Additionally, the forecast is for average weather conditions, whereas 2010 and 2011 were wetter and cooler than average, resulting in lower actual demand.

SPU's new official water demand forecast is based on a number of changes, particularly in the following key areas:

- Future Conservation Goals and Programs. The forecast includes the impact of the 2013-2018 Water Use Efficiency Goal and Program, described in the previous section, and the commitment made in the *2007 Water System Plan* for 15 mgd of cumulative savings from 2011 through 2030.

- Passive Savings. The forecast includes reductions in water use due to passive savings, which are those savings resulting from actions taken by customers without SPU intervention. These include purchases of new plumbing fixtures and appliances that meet federal codes adopted in 1992, 2001 and 2002. In addition, the impact of new clothes washer codes scheduled for adoption in 2011and to become effective in 2015[1] are also included. Passive savings in the forecast also reflect the current proportion of fixtures and appliances sold in the market that exceed code, meeting the more stringent Energy Star, Water Sense, and Consortium for Energy Efficiency (CEE) standards, as well as how those proportions are expected to continue shifting in the direction of higher efficiency over time.

- 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 2008 Cascade contract, Seattle will provide a fixed block of 33.3 mgd to Cascade through 2017, and then the block will be increased by 2 mgd to 35.3 mgd in 2018. The block will be reduced by 10 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: Ames Lake Water Association, the City of Carnation, and the City of Snoqualmie. Demands for the first two purveyors are included in the SPU demand forecast.

1 The US Department of Energy has proposed a two phase clothes washer efficiency standard with the first phase effective March 7, 2015, and the second, more stringent phase, effective for Janunary 1, 2018. This federal proposal has yet to be adopted as a final rule..

- Non-Revenue Water. Combined transmission and Seattle distribution system non-revenue water is assumed to increase from 8 mgd in 2010 to 10 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.

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[1] to characterize uncertainty associated with the official demand forecast.

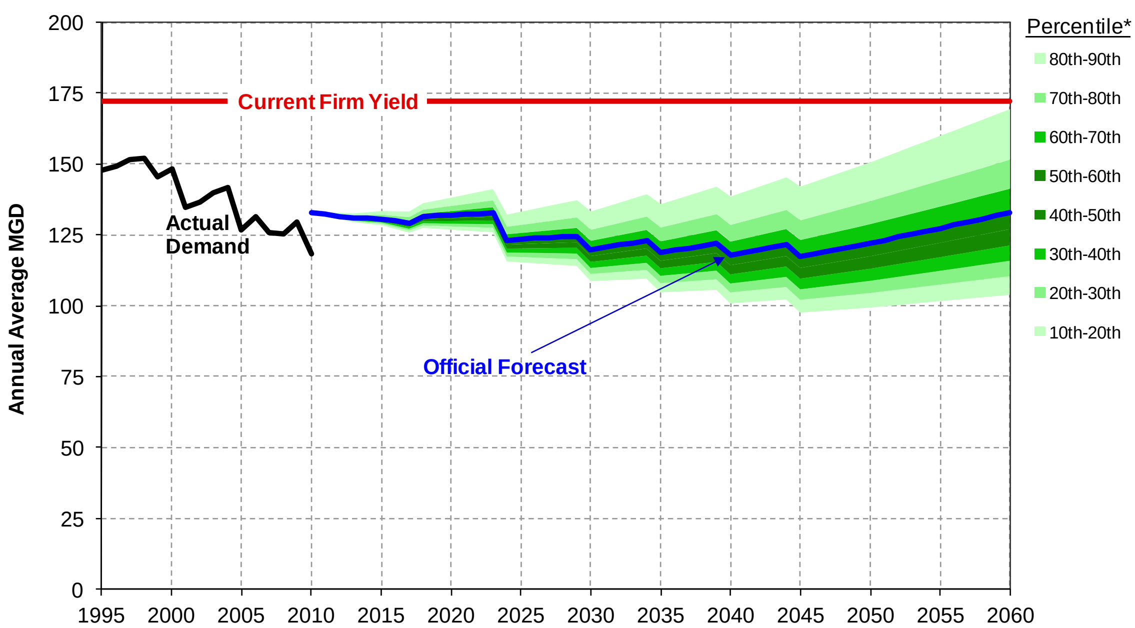


Figure 2-6. Uncertainty in Water Demand Forecast[2]

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[1] 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.

[2] 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 58th percentile.

The results of the Monte Carlo simulation are displayed in Figure 2-6. 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., 104 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., 169 mgd in 2060).

This type of analysis provides insight into the uncertainty that surrounds the various inputs to the demand forecast model. It estimates a more than 90 percent probability that a new source will not be necessary before 2060 given the range of uncertainty in demand that was tested.

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, an increase in demand could occur if a wholesale customer’s own source of supply is significantly less than forecasted and the wholesale customer chooses to have SPU provide for its additional needs. SPU monitors such developments so that adjustments to the forecast can be made when appropriate.

2.4.1.3 Climate Change and Future Supply Outlook

Climate variability and climate change are uncertainties that SPU considers in ensuring that current and future water demands for people and fish are met. Having managed the water supply system for the past century, SPU is accustomed to providing an essential and reliable service in the face of climate variability. In the Pacific Northwest, two major drivers of climate variability are El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO), both of which are natural phenomena that affect meteorological conditions and in turn SPU’s water supply and demand. Climate change is caused by an increase in heat-trapping atmospheric gases, known as greenhouse gases. Climate change can also alter weather patterns and affect air temperatures, humidity, evaporation, cloud cover, rainfall, snowfall, snowpack, and runoff, in terms of averages, extremes, timing and distribution. The timing and magnitude of these changes and their affect on

SPU's water supply and demand is uncertain but better understanding of the implications of climate change for SPU is a programmatic area of focus within SPU. Climate variability and climate change are often used interchangeably but, for purposes of distinction, in this document when SPU refers to climate variability SPU is referring to a phenomenon that is cyclical and natural in nature, while references to climate change denote persistent change that is largely human induced. SPU's policies for Supply Reliability and Planning for Uncertainty require that the potential impacts of long-term climate change on water supply and demand be addressed in developing supply investment strategies based on the most current knowledge and a wide range of climatic conditions.

The *2007 Water System Plan* presented the results of a University of Washington Climate Impacts Group (UW-CIG) study initiated in 2002 on the potential impacts of climate change on SPU's water supply. Since then, and as part of the process that resulted in the Water Supply Forum's *2009 Regional Water Supply Outlook*, SPU evaluated the potential impact of climate change on the future availability of its water supply as well as future water demands using information from a second study conducted by UW-CIG. This evaluation was further updated in developing the *2013 Water System Plan*.

The recent work builds off of a downscaling study[1] completed in 2007 by UW-CIG that explored a range of climate change scenarios produced by model runs that coupled three different global climate models with two different emissions scenarios[2]. UW-CIG used these model runs to create meteorologic datasets for the Central Puget Sound region at four different 31-year time periods centered around 2000, 2025, 2050 and 2075. Individual model projections of average daily air temperature for 2075 produced increases above the 1928-2004 historic period that range from 3.8°F to 9.0°F for summer and from 1.4°F to 8.1°F for winter, when averaged across the stations in the study area. Precipitation changes were less consistent for each model and between models, with changes in seasonal precipitation in 2075

[1] Palmer, R.N. 2007. "Final Report of the Climate Change Technical Committee." A report prepared by the Climate Change Technical Subcommittee of the Regional Water Supply Planning Process, Seattle, WA.

[2] The three global climate models used are the GISS model from the Goddard Institute for Space Studies coupled with Special Report on Emissions Scenarios (SRES) emission scenario B1 ("warm" scenario), the ECHAM model from the Max Planck Institute for Meteorology coupled with SRES emission scenario A2 ("warmer" scenario), and the IPSL model from Institute Pierre Simon Laplace coupled with SRES emission scenario A2 ("warmest" scenario).

relative to the historic period ranging from -29 percent to +11 percent in summer and -6 percent to +48 percent in winter.

Using these datasets, UW-CIG ran hydrologic models that simulate snow accumulation, snow melt and runoff to create streamflow datasets for the major water supply drainage basins in the region. For the primary sites used to characterize inflows into the reservoirs, by 2075 the average of all models across all five basins compared to historic flows decrease by 37 percent during the summer and increase by 48 percent during the winter. SPU used the inflow data from these models to assess the impacts on available supply. In addition, SPU used the temperature and precipitation data to determine how peak season and annual water demands could change in the future under these scenarios.

The results of this assessment indicated that climate change could lead to reductions in supply ranging from 6 percent to 21 percent in 2050 and a possible 4 percent increase in demand under the warmest scenario. SPU identified a series of adaptation options and modeled how effective they would be in offsetting the reductions of supply. In two of the three scenarios in 2050, the adaptation offsets would fully compensate for the reductions in supply. In all of the scenarios there would be sufficient supply to meet demand if adaptation options were deployed.

Updated climate change analyses show less of an impact on water supply availability than previous studies because of the updates to assumptions to the firm yield estimates and lower forecasted water demands.

SPU's analysis was updated in 2011 to include the same assumptions used in the latest firm yield estimate, including the recently authorized higher refill level of 1563 feet for Chester Morse Lake, as well as the latest water demand forecast. This analysis is based on meeting water demands at 98 percent reliability after satisfying instream flow requirements and limiting diversions from the Cedar River according to the MIT Agreement, as described in the *2007 Water System Plan*. The analysis also assumes that an improved Chester Morse Lake Pump Plant and associated facilities would allow normal access to water stored between elevations 1538 and 1532 feet in Chester Morse Lake.

Under the three model scenarios, the impact of climate change on supply and demand would increase over time, with the greatest impact occurring with the warmest scenario. Assuming no change in system operations, available supply under the warmest scenario is estimated to be reduced by as much as 4 percent in 2025, 6 percent in 2050, and 13 percent in 2075. The reduced supply would exceed forecasted demand for all years. However, under the warmest scenario, average annual demand is estimated to increase by 1 percent in 2025, 2 percent in 2050, and 5 percent in 2075, assuming no change in forecasted demographics and no new conservation programs to reduce this increase. Even so, the reduced supply would still exceed climate-impacted demands for all years except 2075, in which demand would exceed supply by approximately 3 percent.

For this scenario, SPU identified system modifications that could be pursued to mitigate the reductions in supply from climate change. These modifications are no or low cost options that would increase useable storage to capture more of winter runoff for release during the summer. These options include:

- Chester Morse Lake refilled to 1566 feet: current refill is to 1563 feet; adds more than 6,000 acre-feet or 11 percent more storage in the Cedar system with no new infrastructure and no change to water rights.

- South Fork Tolt Reservoir drawdown to 1690 feet: current minimum is 1710 feet; adds 7,500 acre-feet or 18 percent more storage in the Tolt system with no new infrastructure and no change to water rights.

- Overflow Dike at 1554 feet: crest is currently at 1550 feet; change would store 6,500 acre-feet in Chester Morse Lake, reducing seepage to the moraine and loss to the Snoqualmie River Basin. This option is under study as a repair alternative and would require modifications of existing infrastructure and amendments to the Cedar River Habitat Conservation Plan.

These system modifications would essentially restore supply to historic levels. Under the warmest scenario in 2075, the available supply with these system modifications would exceed forecasted climate-impacted demands by almost 10 percent if all modifications are made. Additional options to manage the impacts on supply may be possible through optimization of system operations.

The results of this analysis indicate that no new source of supply is needed before 2060 (the ending year of the official demand forecast) even when potential climate change impacts are considered. This updated evaluation shows less of an impact on water supply availability than previous studies because of the updates to assumptions to the firm yield estimates and lower forecasted water demands. Even so, future climate change could potentially increase the frequency of low reservoir levels and for requests to customers to curtail water use, depending on the system modifications that are implemented and the timing and magnitude of climate change impacts.

The above analysis does not assess the effect of climate change on several key factors that influence water resources and supply operations. For example, climate change impacts on water quality, particularly the frequency of high turbidity events and algal blooms that can be disruptive to supply operations, have not been evaluated but can reduce supply availability. Also, changes to the watershed forests and potential increases in fires have not been assessed, but could have a significant impact on hydrology and water quality. SPU's water supply could also be affected if climate change were to significantly delay the return of fall rains or lead to sustained droughts of longer duration than those experienced in the past. These issues are a sampling of topics for further research and analysis.

It is anticipated that some of these issues will be considered through SPU's next impacts assessment, which SPU will initiate in 2012. SPU is participating in a collaborative venture between Water Utility Climate Alliance members and climate researchers called Piloting Utility Modeling Applications (PUMA[1]). PUMA is intended to identify state of the art climate modeling tools and techniques to generate climate data that utilities can use to conduct impacts assessments and inform the development of adaptation strategies. In conducting its assessment through PUMA, SPU intends to use the next generation of climate data and will share the results of this assessment when it is finalized. Given the dynamic nature of climate research, SPU is committed to remaining engaged in future research, conducting new assessments on a periodic basis to identify potential impacts and system vulnerabilities, and planning for adequate water supply while ensuring that decisions do not result in unnecessary or premature financial and environmental costs for the region.

2.4.1.4 Future Supply Opportunities

While both the firm yield update and climate change analysis indicate that no new supply is needed well into this century to meet forecasted demand, the supply alternatives identified in the *2007 Water System Plan* remain as opportunities for SPU to consider should future forecasts indicate the need to develop a new supply source. Included in the list of alternatives is reclaimed water, and because new information is available, that alternative is discussed more fully here.

[1] For additional information about PUMA see: http://www.wucaonline.org/html/actions_puma.html

Over the past decade, SPU has engaged in several evaluations of providing reclaimed water as an alternative to its potable supply. None were implemented, however, because projects were either not cost-effective or not welcomed by the potential user.

With the Brightwater Treatment Plant, there is an opportunity for large volumes of reclaimed water to be distributed in the north part of the SPU service area. The Brightwater Reclaimed Water Backbone Project will be able to carry up to up to 9 mgd south to large non-potable water users in the Sammamish River valley, and about 12 mgd west to northern King County to the Ballinger Way portal. The Ballinger portal is at the very northern end of SPU's retail service area.

Knowing that King County is interested only in selling reclaimed water wholesale to potential retail distributors such as SPU, SPU conducted an economic analysis of the potential use and cost-effectiveness of distributing reclaimed water from the Brightwater portal to large irrigators and other potential users of non-potable water in the north part of SPU's retail service area. The analysis is summarized in *An Economic Analysis of the North Seattle Reclaimed Water Project* completed by SPU in 2010.

For the analysis, a total of 50 potential customers with 1.7 mgd of potential use were identified. Distribution of the reclaimed water would require 27 miles of pipeline plus pumping facilities at a cost of $87 million in initial capital improvements and $109 million in total life-cycle costs, as well as any on-property improvements. Both the supply and environmental benefits of this project were determined to be minimal.

The overall conclusion of the analysis was that the proposed North Seattle Reclaimed Water Project would not be a sound investment for the region due to high costs, a low level of benefits, and the availability of lower-cost alternatives for achieving comparable benefits.

2.4.2 Infrastructure Needs and Improvements

SPU maintains its water resources facilities for safe and reliable operation to ensure water supply is available for its customers. Several infrastructure improvement projects and operational studies have been identified to improve the reliability and flexibility of the existing water supply system. These projects and studies are described below.

2.4.2.1 Morse Lake Pump Plant Project

The Chester Morse Lake floating barge pump system is intended to be used to access water in storage when levels in the lake are below elevation 1538 feet. Pumping provides additional flow to the Masonry Pool and the Cedar River to meet customer needs and instream flow requirements.

The Morse Lake Pump Plant option selected for further analysis, design and implementation is a new floating pump system using purchased mobile diesel generators and additional channel improvements.

In recent years, maintenance work has been completed in an attempt to achieve operability and restore flow capacity of the pumping plants and associated facilities. This work included maintenance dredging of the channel, testing and replacing electrical cable, and making electrical mechanical safety improvements and repairs. Even with these improvements and repairs, 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 due to the need to rent and install mobile diesel generators that power the pumps. Up to two months are needed to ready the plants, which can lead to costly efforts that later prove to be unnecessary when the plants are then not subsequently needed or put to use.

SPU completed preliminary engineering and value engineering studies to evaluate options for repairing or replacing the current floating barge pump system. The Morse Lake Pump Plant option selected for further analysis, design and implementation is a new floating pump system using purchased mobile diesel generators and additional channel improvements. This project is currently in the implementation phase.

2.4.2.2 Overflow Dike Replacement

The existing Overflow Dike used to separate Cedar Lake from Masonry Pool has wooden flashboards with the tops at elevation 1550 feet. The top of the Overflow Dike structure is at elevation 1555 feet, with the invert of the dike notch at 1546 feet. The wooden flashboards were damaged in 2008 during a flood event. SPU will conduct an analysis to determine if a variable crest dam replacement for the flashboards would be beneficial. One benefit of a variable crest dam would be improved flood management by allowing a faster flood pocket recovery. A part of this analysis will include the evaluation of the potential benefits of having a higher elevation for the top of the flashboards, up to elevation 1554 feet. The additional four feet of elevation would be useful in allowing an earlier pool split, saving water in Cedar Lake and reducing seepage at Masonry Pool. The analysis will also include the environmental impacts of higher pool levels during the pool split period.

2.4.2.3 Refill of Chester Morse Lake to 1566

One of the projects evaluated as a part of the Operations and Optimization Study was raising the refill level of Chester Morse Lake to elevation 1566 feet. This analysis will be continued to further determine feasibility and costs. Just as raising the refill level to elevation 1563 feet added storage and resulted in an increase to firm yield, raising the refill level to 1566 is expected to do the same. The benefits of the higher refill could be optimized in conjunction with an increase in the Overflow Dike as described above. The feasibility analysis will also preliminarily investigate the impacts of the higher refill level on tributary habitat, flood management issues, moraine seepage and dam safety.

2.4.2.4 Landsburg Flood Passage Improvements

Since the Cedar River flooded in fall 1990, there have been concerns about flood debris, such as large trees uprooted during high flows, blocking the spillway gates at Landsburg Diversion Dam during major floods. SPU has completed new studies of large woody debris management since completion of the *2007 Water System Plan*, and this information will be used to update the evaluation of flood passage at the Landsburg Diversion Dam. SPU is in the process of reviewing the options for structural modifications of the Landsburg Dam and non-structural approaches that include increased log handling during storm events. Analyses have been completed on preliminary engineering and life-cycle cost analyses to improve the flood passage capabilities at the dam using modifications to existing spill gates, large woody debris handling upstream, and modifications to the south abutment to allow passage of the 500-year design storm. These approaches 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 and impede the delivery of water.

2.4.2.5 Lake Youngs Cascades Dam

Water stored in Lake Youngs is impounded by two earth embankments, the Outlet Dam to the south and Cascades Dam to the east, and the perimeter dikes around the lake. A third dam, Inlet Dam, east of Cascades Dam, normally does not store water and was constructed as a backup embankment to retain the reservoir water in case of a failure of Cascades Dam, which shows signs of movement and is considered to be somewhat unstable. As noted previously, SPU plans to conduct further investigations and studies to determine the potential impact on water quality that could be caused by failure of Cascades Dam, particularly with respect to material existing in the area between Cascades Dam and the Inlet Dam.

2.4.2.6 South Fork Tolt Reservoir Studies

As noted in the *2007 Water System Plan,* there is potentially significant benefit to expanding the historical operating range of the South Fork Tolt Reservoir. SPU plans to conduct studies and analyses to increase the understanding of the constraints and environmental issues associated with South Fork Tolt Reservoir operations to support drawdown below elevation 1710 feet.

2.5 IMPLEMENTATION/ACTION PLAN

In the absence of a need to develop new water supplies for several decades, SPU's implementation/action plans in the Water Resources business area will focus on continuing conservation efforts, improving infrastructure reliability and operational flexibility to optimize existing supply, and pursuing additional work to assess climate change impacts. A summary of the implementation/action plan for the Water Resources business area is as follows:

- Reduce per capita water use from current levels so that total average annual retail water use of members of the Saving Water Partnership is less than 105 mgd from 2013 through 2018 despite forecasted population growth.
- Continue to implement water conservation efforts that help low-income customers in Seattle manage their water bills.
- Complete infrastructure and operational improvements:
  - Implement the Morse Lake Pump Plant Project to recover water from Chester Morse Lake during low water level conditions and other emergencies.
  - Investigate raising the Overflow Dike to elevation 1554 feet and using a variable crest dam for that purpose.

  - Complete investigations that are required to determine if the Chester Morse Lake refill elevation can be raised to elevation 1566 feet.

  - Implement the Landsburg Dam Flood Passage Improvements.

  - Conduct further investigations to determine the potential impact on water quality that could be caused by failure of Lake Youngs Cascades Dam and potential improvements to mitigate this risk.

  - Learn more about what level of additional drawdown the South Fork Tolt Reservoir can accommodate to support additional future supply.

- Remain engaged in future research on climate change by participating in the PUMA project, conducting new assessments on a periodic basis to identify potential impacts and system vulnerabilities, and planning for adequate water supply while ensuring that decisions do not result in unnecessary or premature financial and environmental costs for the region.

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Chapter 3
Water Quality and Treatment

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 *2013 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 from the supply source to the customers' 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, ensuring appropriate monitoring of water quality for regulatory and operational purposes, managing distribution system water quality, overseeing water quality and treatment related capital improvement projects, and participating in other water system projects that have the potential to impact water quality. The Water Quality and Treatment business area is unlike other business areas in that its programs affect infrastructure and practices in the Major Watersheds, Water Resources, Transmission and Distribution 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 Accomplishments Since 2007 WSP

Since completion of the *2007 Water System Plan*, SPU has implemented the following major improvements in the Water Quality and Treatment business area:

- Reservoir Covering/Burying: Reconstructed the following from open reservoirs to covered reservoirs to improve water quality, increase security, and create new public open space opportunities:
    - Myrtle Reservoir (2008)
    - Beacon Reservoir (2009)
    - West Seattle Reservoir (2010)
    - Maple Leaf Reservoir (2012)

- Kerriston Road: Purchased approximately 148 acres to increase control of lands accessed by Kerriston Road through the lower Cedar River Watershed, avoid future risk and costs associated with illegal trespass in and around the Cedar River Watershed, and reduce risk and liability costs associated with continuing residential build-out of the Kerriston community (2011).

- Laboratory Information Management System (LIMS): Implemented an updated LIMS system at SPU's Water Quality Laboratory to allow for efficient sample scheduling, coordination of analyses, recording of results, quality assurance/quality control tracking, and data retrieval (2007).
- Cross-Connection Control: Set up and installed a database for management of the cross-connection control program, which includes the oversight of over 20,000 backflow assemblies in the city (2009). The database made possible a new enforcement strategy implemented in 2011 which greatly improved compliance with backflow assembly testing requirements. The backlog of assemblies overdue for testing was reduced from fifteen percent down to four percent.

3.2 SERVICE LEVEL PERFORMANCE

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 WDOH 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 (i.e., taste, and odor). SPU has been successful in meeting this service level. Since the *2007 Water System Plan* was developed, SPU met all drinking water regulatory requirements. SPU has a Reservoir Covering Plan approved by Washington State Department of Health (WDOH) that is being implemented ahead of schedule (see Section 3.3.6.1). More information on how SPU is meeting regulations is provided in the remainder of this chapter.

3.3 EXISTING FACILITIES AND PRACTICES

SPU's water system includes 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 standards.

To achieve its water quality and treatment service level, SPU has expended a great deal of effort over the past decades and continues to make concerted efforts in order to ensure compliance with WDOH drinking water regulations. SPU operates its 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.

3.3.1.1 Total Coliform Rule

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

The Total Coliform Rule requires monitoring to demonstrate that a water system is operating and maintaining its distribution system in a way that minimizes the risk of bacterial intrusion or regrowth. 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 facilities and covered reservoirs, have been implemented over recent years, Seattle's success in meeting the total coliform rule requirements have improved greatly.

As indicated by Figure 3-1, SPU has been continuously in compliance with the Total Coliform Rule. Since the startup of the Cedar Water Treatment Facility in August 2004, SPU has been well within the regulatory requirement of less than 5 percent of samples with detectable total coliform. The highest detection month since August 2004 was 2.1 percent, which occurred in July 2008.

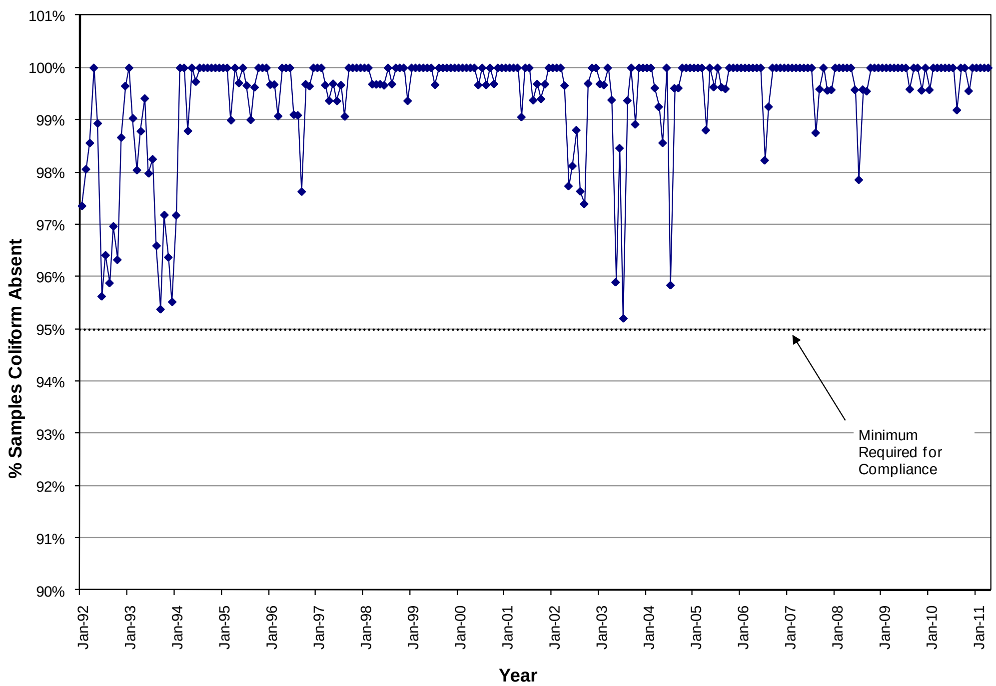

Figure 3-1. Monthly Coliform Data from SPU Water Distribution System

There have been over 15,000 coliform samples collected since January 2006. Of those 15,000 distribution samples, 27 have been positive for total coliform, and two have been positive for *E. Coli*. All follow-up sampling for the *E. Coli* positive samples showed no indication of contamination, and compliance with the Total Coliform Rule was met. Public notification was not required.

3.3.1.2 Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) contains disinfection and filtration requirements for all public water systems that use surface water supplies. Several revisions to the original rule have been made since 1989, with the latest revision being the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).

Tolt Supply. With completion of the Tolt Water 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 Water Treatment Facility operations contract includes water quality performance requirements that meet and, in most cases, exceed the regulatory filtration and disinfection requirements. The Tolt Water Treatment Facility has had no treatment violations since startup.

Cedar Supply. Construction of the Cedar Water Treatment Facility was completed in 2004. The Cedar River supply has a regulatory designation known as a "Limited Alternative to Filtration" (LAF), 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. The Cedar supply continues to operate in compliance with the LAF criteria.

Like the Tolt Water Treatment Facility, the Cedar Water 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 Water Treatment Facility has experienced no treatment violations.

Long Term 2 Enhanced Surface Water Treatment Rule. The LT2SWTR, focuses on controlling *Giardia* and *Cryptosporidium* in surface water supplies. This rule affects the Seattle water system in two ways: source monitoring for *Cryptosporidium* and covering of open distribution reservoirs. The source monitoring for *Cryptosporidium* is now complete. The results for both the Cedar and Tolt were in the lowest category (highest quality), so no changes are needed to the existing treatment provided.

The LT2ESWTR also requires that open, treated-water reservoirs be covered or provided with treatment on the outlet. SPU already had a reservoir covering plan approved by WDOH when the LT2EWTR was issued. SPU reaffirmed its covering plan with DOH in 2009. SPU's reservoir covering program is described in further detail later in this chapter.

3.3.1.3 Groundwater Rule

The Groundwater Rule was issued in November of 2006 and went into effect in 2009. SPU has not used its wells for production purposes since the rule has been in effect. SPU's wells draw from a deep aquifer that is well protected from contamination. When the Seattle Wells are next used, SPU's plan for compliance is to conduct triggered source water monitoring as necessary. While not part of the current regulatory compliance strategy, chlorine contact time for disinfection of viruses is achieved in the pipelines a short distance from the wells.

3.3.1.4 Disinfection By-Products Rule

In general, Seattle's high quality source water and upgraded treatment result in low concentrations of disinfection by-products (DBPs), such as trihalomethanes and haloacetic acids, by-products that can result from reactions between chlorine and natural organic matter. Trihalomethane and haloacetic acid monitoring results since 2006 are presented in Figure 3-2 and Figure 3-3. The results are all well below the regulatory limits. Historically, disinfection by-product levels have been relatively low in the Cedar River water. Disinfection by-product levels in the South Fork Tolt River water decreased substantially with startup of the Tolt Water Treatment Facility and are now comparable to those of the Cedar source.

SPU has completed the Stage 2 DBP Rule Initial Distribution System Evaluation (IDSE) sampling program that identified sites in the distribution system where the highest disinfection by-product levels were likely to be found. Based on IDSE testing results, SPU does not anticipate any difficulty meeting the by-product limits under the new rule.

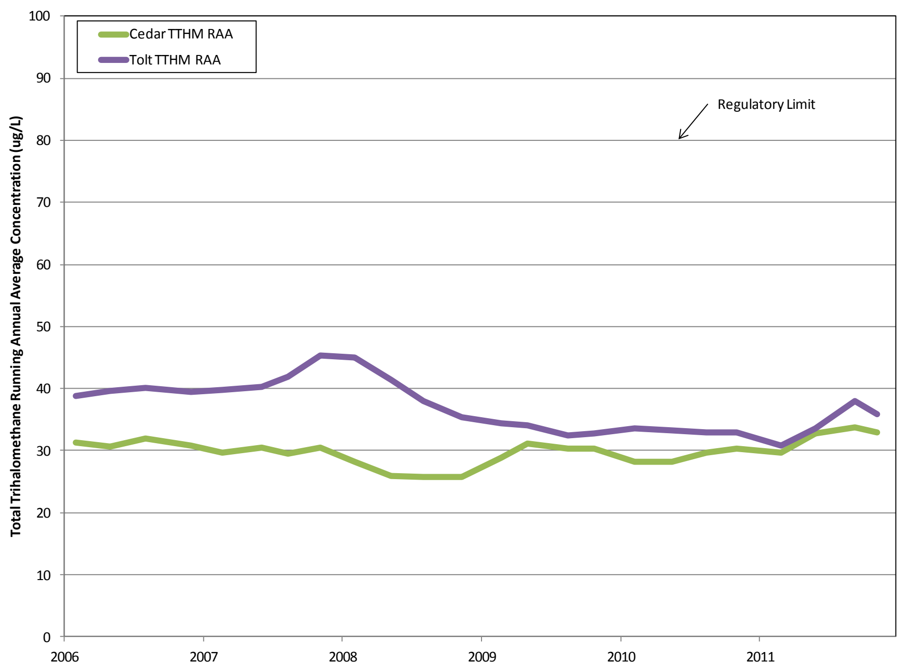

Figure 3-2. Trihalomethane Concentrations, 2006 to 2011

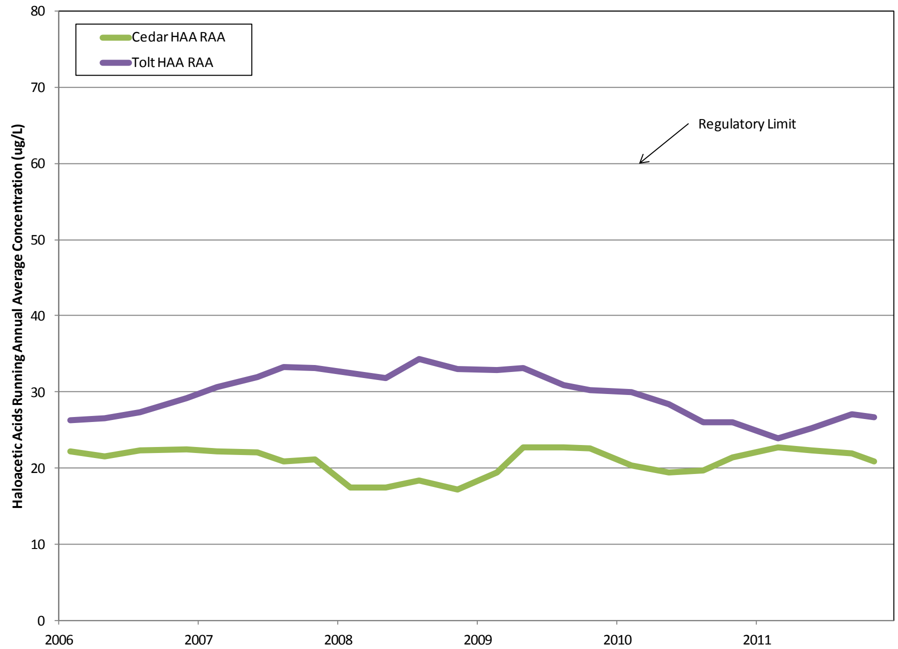

Figure 3-3. Haloacetic Acid Concentrations, 2006 to 2011

3.3.1.5 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. These components can leach lead and copper into the water.

Beginning in 2005, compliance for Seattle's Regional Lead and Copper Monitoring Program was divided into sub-regions. Compliance for Seattle has been based on samples collected from the Seattle direct service area only since 2005. Compliance for the other sub-regions (Bellevue, Tolt Wholesale, and Cedar Wholesale) is based on results from those sub-regions.

The Lead and Copper Rule requirement is to be below 15 ug/L for lead, and below 1,300 ug/L for copper, with both at the 90^{th} percentile. Seattle's 90^{th} percentile lead levels since 2005 have been between 5.0 to 6.4 ug/L, well below the lead action level. For copper, Seattle's 90^{th} percentile levels have been between 120 to 160 ug/L. These levels have allowed Seattle to conduct reduced monitoring for lead and copper. Fifty samples are now collected once every three years from qualified homes in the Seattle direct service area. The next sampling period for the Seattle subregion will occur in 2013.

3.3.2 Other Water Quality Monitoring

SPU conducts a range of other regulatory and non-regulatory water quality monitoring throughout the water system.

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 Reservoir 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 covered storage facilities as part of its routine water quality monitoring program. The information guides system operations, reservoir turnover, spot disinfection, and decisions about when 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.

Emerging Contaminants. Emerging contaminants are not regulated, they are generally new to drinking water scientists, and there is typically limited information about their occurrence and health effects. EPA requires water systems to perform monitoring for some of these contaminants in order to learn about their occurrence. In addition, SPU has chosen to test for other emerging contaminants for its own information and to inform the public. Details of this monitoring are described later in this chapter.

Miscellaneous Monitoring. SPU also conducts extensive 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. This water quality information is used to better understand the conditions in the water bodies, to learn about potential shifts or changes with significance to the drinking water supply, and to inform decisions about water treatment and other system operations.

3.3.3 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.

3.3.3.1 Watershed Protection

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

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, including the Lake Youngs Reservation, to ensure that SPU's source water remains of high quality and free from contamination. These programs are described in SPU's *Watershed Protection Plan*, which details SPU's ongoing efforts to control activities that have the potential to adversely affect water quality in both of its surface water supplies. The latest Plan was approved by WDOH in 2011.

3.3.3.2 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 well field and the Boulevard Park well, located in SeaTac. As part of the *2001 Water System Plan*, SPU prepared and WDOH approved a wellhead protection program, including an inventory of potential contaminants. The program has not changed since 2001, except for the updates to the potential contaminant inventory completed every other year. After each update is completed, notification letters are sent to businesses handling or storing potential contaminants within or near the wellhead protection area, as well as to agencies that have influence over activities in the wellhead protection area, including King County Department of Natural Resources and Parks, Groundwater Protection Program. These letters contain maps of the wellhead protection area boundaries and steps that businesses can take to protect the groundwater supply from contamination.

3.3.4 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.

Table 3-2. Water Quality Characteristics of SPU's Source Water 2007-2011

Surface Water Sources	Cedar River/Landsburg		Cedar River/Lake Youngs Outlet		South Fork Tolt River/Regulating Basin	
Parameter and Unit	**Average**	**Typical Range**	**Average**	**Typical Range**	**Average**	**Typical Range**
Turbidity, NTU	0.8	0.2 – 2.0	0.4	0.2 – 1.0	0.7	0.2 – 2.2
Temperature, °C	9	5 - 13	12.4	6 - 20	8.7	3 - 14
pH	7.6	7.3 – 7.9	7.7	7.1 – 8.5	7.4	7.0 – 7.8
Alkalinity, mg/L as $CaCO_3$	22	14 - 30	19	16 - 25	6.6	5.0 – 7.0
Conductivity, umhos/cm	55	36 - 75	57	48 - 70	23	20 - 25
UVA (@254 nm), cm-1	0.025	0.01 – 0.05	0.017	0.01 – 0.023	0.05	0.04 – 0.06
Total Organic Carbon, mg/L	0.75	0.4 – 1.1	0.8	0.6 – 1.0	1.3	1.1 – 1.6
Total coliform, per 100 mL	310	40 - 700	660	0 - 2400	53	1 - 225
Fecal coliform, per 100 mL	10	0 - 23	<1	0 - 3	<1	0 - 2

Groundwater Sources	Boulevard Well		Riverton Wells	
Parameter and Unit	**Average**	**Typical Range**	**Average**	**Typical Range**
Temperature, °C	11	10 - 12	10	9 - 11
pH	7.0	6.8 – 7.1	7.8	7.7 – 7.9
Alkalinity, mg/L as $CaCO_3$	143		85	83 - 87
Hardness, mg/L as $CaCO_3$	148		107	
Conductivity, umhos/cm	313		243	241 - 245

Contaminants of concern that have been identified in the wells include radon in all of the wells and trace levels of dacthal mono- and di-acid degradates in the Riverton Wells. Radon is a naturally-occurring element found in groundwater sources. Dacthal is an active ingredient in herbicides and is found in soils wherever it is used. These contaminants are currently not regulated by the EPA.

3.3.5 Source Treatment Facilities

As described below, treatment facilities located at both surface water sources and at the well locations are operated to provide high-quality finished water to the regional system.

3.3.5.1 Cedar Supply Treatment Facilities

SPU operates two facilities to treat Cedar River source water, the Landsburg Water Treatment Facility and the Cedar Water Treatment Facility.

Landsburg Water Treatment. At the Landsburg Water Treatment Facility, SPU fluoridates and chlorinates the Cedar supply. Prior to the construction of the Cedar Water Treatment Facility at Lake Youngs in 2004, the Landsburg Water Treatment Facility was the primary disinfection site for water from the Cedar River watershed. The chlorine addition at Landsburg now serves to minimize microbial growth in the transmission pipeline between Landsburg and Lake Youngs and to aid in the control of new organisms (e.g., algae from Chester Morse Lake) entering Lake Youngs.

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

Cedar Water Treatment Facility. The Cedar Water Treatment Facility uses ozone, UV, and chlorine applied in series to ensure inactivation of *Giardia*, *Cryptosporidium*, and viruses. The ozone process also improves the taste and odor of the water from this source. Lime is added at the facility in order to reduce the corrosivity of the water to in-premise plumbing. The new facility has a capacity of 180 mgd.

The Cedar Water Treatment Facility is operated under contract by CH2M HILL OMI with oversight from SPU. The operations contract began in late 2004. In both 2019 and 2024, the 15- and 20-year marks of the contract, SPU will have the option to renew the existing contract for 5 more years, hire another operations contractor, or use SPU staff to operate the treatment facility.

3.3.5.2 Tolt Water Treatment Facility

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, chlorination, and adjustment of pH and alkalinity for corrosion control.

The Tolt Water Treatment Facility is operated by American Water / Camp Dresser & McKee with oversight from SPU. The 15-year operations contract began in 2001. In 2016 and 2021, SPU will have the same 5-year contract renewal options as it has for the Cedar Water Treatment Facility.

3.3.5.3 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 normally blended before delivery to SPU customers. Treatment of well water is maintained under normal circumstances, though for emergency supply the wells could be started and run for a short period of time prior to startup of the treatment systems.

3.3.5.4 Condition of Source Treatment Facilities

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

Because of their recent construction, the Cedar and Tolt Water Treatment Facilities are both in excellent condition. Condition assessment of the major equipment is performed on an annual basis and preventative maintenance is ongoing. No major equipment replacement is currently planned. Equipment at the well treatment sites is generally in very good condition. Some components with shorter lifespan have been replaced as needed, but no major replacements are planned.

The older Landsburg Water Treatment Facility is outdated, and SPU is in the process of implementing an alternative to replace the building and upgrade the SCADA systems. In addition, the decision has been made to replace the existing chlorine feed system with sodium hypochlorite for risk management purposes.

3.3.5.5 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 (2007-2010)		Tolt River (2007-2010)	
Parameter and Unit	**Average**	**Typical Range**	**Average**	**Typical Range**
Turbidity, NTU	0.4	0.2 – 0.9	0.06	0.04 – 0.10
Temperature, °C	12.7	5 – 22	9	3.5 – 15
pH	8.2[a]	8.0 – 8.4	8.2[a]	8.0 – 8.4
Alkalinity, mg/L as $CaCO_3$			19[a]	18 – 20
Conductivity, umhos/cm	67	55-77	61	56-66
UVA (@254 nm), cm^{-1}	0.010	0.007-0.013	0.012	0.010-0.014
Chlorine residual, mg/L	1.5[a]	1.4 – 1.7	1.5[a]	1.4 – 1.6

Groundwater Sources	Boulevard Park Well (2000-2010)[b]		Riverton Wells (2000-2010)[b]	
Parameter and Unit	**Average**	**Typical Range**	**Average**	**Typical Range**
Temperature, °C	12	10 - 14	11	9 - 12
pH	8.25[a]		8.25[a]	
Alkalinity, mg/L as $CaCO_3$	112		80	
Conductivity, umhos/cm	330	285 - 362	218	206 - 255
Chlorine residual, mg/L	1.0[1]		1.0[a]	

[a] Treatment target or criterion

[b] Wells are used infrequently, so data set is relatively small.

3.3.6 In-Town Storage Facilities

SPU operates several water storage facilities downstream of its Cedar and Tolt Water Treatment Facilities, 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 upon request.

3.3.6.1 Reservoir Covering/Burying

SPU is nearing completion of its open reservoir covering program. The approach for covering the open reservoirs has remained closely on track with that outlined in the *2007 Water System Plan*, and has focused on replacing SPU's open reservoirs with new buried structures to improve water quality, increase security, and create new public open space opportunities. Although new park space will be a feature at many of the new buried reservoir sites, the paramount purpose of these sites remains as the storage and distribution of city water supplies and the safety of the drinking water. The replacement projects represent a significant amount of work. Table 3-4 summarizes the covering program and completion dates.

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	21.5	21.3	2001[a]
Lake Forest Park	60	60	2003[a]
Lincoln	20	12.7	2006
Myrtle	7	5	2008
Beacon	61	50	2009
Roosevelt	50	0[b]	2015[b]
West Seattle	68	30	2010
Maple Leaf	60	60	2012
Volunteer	20	0 or 10[b]	2015[b]
Total	**367.5**	**239 (or 249)**	

[a] Floating cover replacement options, including buried storage, will be evaluated at end of useful life of floating cover (i.e., in about 10-15 years).

[b] Roosevelt and Volunteer Reservoirs are planned to be removed from service following the completion of the new buried Maple Leaf Reservoir—see text below for more information. Roosevelt is shown here as decommissioned, and Volunteer is shown as either decommissioned or downsized to 10 MG.

Construction of the new buried Maple Leaf Reservoir is planned to reach substantial completion in 2012. The only two remaining open reservoirs (Roosevelt and Volunteer) are planned to be removed from service following the completion of Maple Leaf Reservoir. They will remain out of service for several years to gain operational experience, and to confirm analytical conclusions that system reliability will not be affected by their decommissioning.

Why did we have to cover the reservoirs?

Federal regulations require that all treated drinking water reservoirs be covered. SPU installed floating covers on two reservoirs, and is replacing its other open reservoirs with underground structures that both improve the quality and security of our water system and provide 76 acres of new open space for everyone to enjoy.

3.3.6.2 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.

3.3.6.3 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. When major maintenance or upgrades are performed on tanks and standpipes, such as interior painting, SPU has been making modifications 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. The completed Myrtle Tank project included separation of the inlet and outlet piping as well as sample taps at multiple levels. The ongoing Richmond Highlands Tank project has a mixing system and multiple sample taps as part of the design.

3.3.6.4 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. SPU’s addition of filtration treatment on the Tolt supply back in 2001 along with the reservoir covering program that is now nearing completion have reduced the amount of chlorine addition in the distribution system previously necessary. 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 have been converted to sodium hypochlorite, except in one case where the facility is scheduled for decommissioning. 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.

3.3.7 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, responding to customer complaints, storage reservoir cleaning, testing and flushing watermains, and maintaining transmission pipeline water quality. Each activity is summarized below.

3.3.7.1 Comprehensive Water Quality Monitoring Plan

A comprehensive monitoring plan was updated in 2011 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.

3.3.7.2 Cross-Connection Control Program

SPU implements a cross-connection control program in order to protect the quality of the water supply from cross connections. Within Seattle and the retail service area south of Seattle, SPU's cross-connection program is a joint undertaking with Public Health Seattle-King County (PHSKC). Within the City of Shoreline, SPU works with Shoreline city staff members. The program includes elements to isolate and disconnect cross-connections both within the customer's premises and at the service connection. The cross-connection control policy and procedures were included with the *2007 Water System Plan*.

Under the cross-connection control program, SPU oversees more than 20,000 backflow assemblies owned by customers within SPU's retail service area. In 2009, SPU implemented a new database for management of the cross-connection control program. This database has enabled staff to more efficiently and more accurately ensure that these backflow assemblies are protecting the drinking water supply. The database made possible a new enforcement strategy implemented in 2011 which greatly improved compliance with backflow assembly testing requirements. The backlog of assemblies overdue for testing was reduced from fifteen percent down to four percent

3.3.7.3 Customer Complaint Response

SPU has procedures for responding to complaints and problems reported by its retail customers about drinking water quality. The vast majority of complaints concern discolored water. Discolored water comes from internal pipe rust and sediment getting stirred up. It is an inconvenience, but does not represent contamination of the water supply. From 2006 to 2010, an average 1,500 water quality complaints were received per year. This is for a customer base of 188,000 connections. Figure 3-4 shows the breakdown of the types of complaints for that period.

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

The process for receiving complaints puts the customer in immediate contact with SPU staff and provides SPU with up-to-date knowledge of where the complaints are coming from, the nature of the complaints or problems, and how many calls are being received from a given area of Seattle. SPU logs the complaint information in a computer system and is able to bring these complaints up on a map for further analysis. Because the cause of a problem is usually not known at the time a complaint is called in, improvements are planned to allow revision of complaint data after follow up with the customer so that if the probable cause of the problem is determined, it can be noted and tracked.

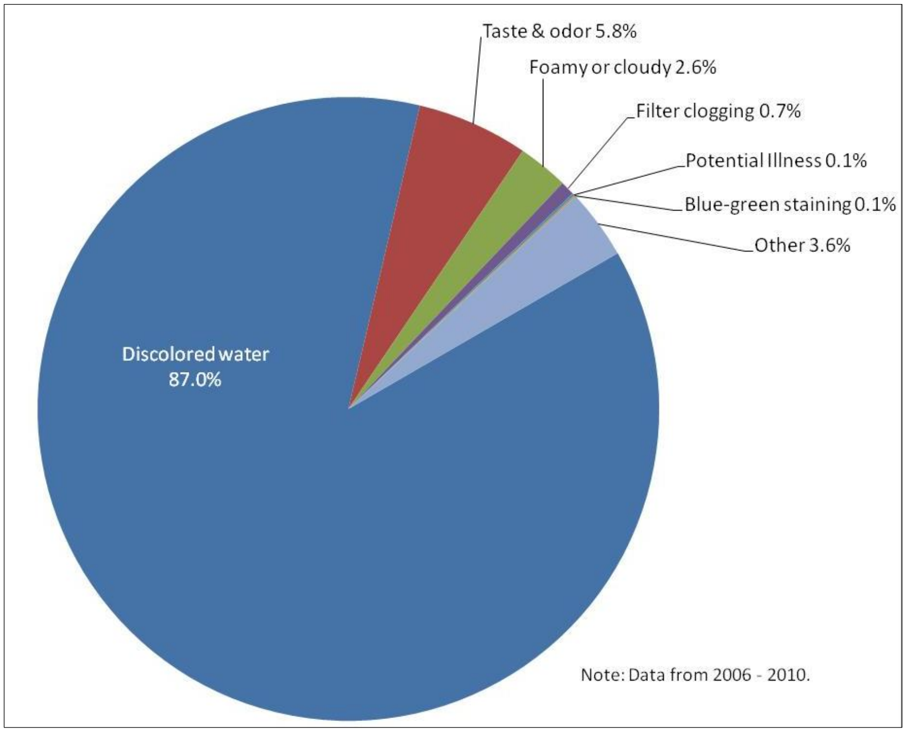

Figure 3-4. Types of Water Quality Complaints

3.3.7.4 Transmission and Distribution Storage Facility Cleaning

A key to maintaining water quality after the treated water enters the transmission and distribution system is making sure that storage facilities are regularly cleaned. SPU ensures its in-town, open reservoirs are drained and cleaned at least annually. SPU monitors water quality analytical results and customer complaints to identify trends that would indicate more frequent cleaning is necessary. Currently, Roosevelt Reservoir is scheduled for cleaning in the spring, and Volunteer Reservoir is scheduled for cleaning in the fall. Cleaning employs high-pressure washing equipment to remove algae and debris buildup; then the facilities are disinfected and sampled before they are put back into service.

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 3-5. 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 3-5. Closed Storage Cleaning Schedule

Type of Reservoir	Frequency of Cleaning
Elevated tanks or standpipes	3-5 years - Cedar supply and/or if interior coating is in poor condition 10-15 years - Tolt supply
Hard-covered reservoirs	3 -5 years - Cedar supply Variable - Tolt supply[1]
Floating covered reservoirs	Variable – Tolt supply[1]
Floating covers (top of cover only)	1 time per year

[1]Cleaning frequency depends on dive inspection results.

3.3.7.5 New Water Main Testing

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

3.3.7.6 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. There is currently a two-person crew dedicated to water main flushing. SPU is planning to review its flushing practices and its level of resources allocated to flushing.

3.3.7.7 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. 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. Although pH is typically not a health issue, unless it becomes extremely low or extremely high, customers may find that water with moderately elevated pH tastes or feels different than that to which they are accustomed. Higher pH can also decrease the effectiveness of chlorine for disinfection. Additional customer concerns could include loss of aquarium fish or adverse impacts on commercial and industrial facilities.

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

3.3.8 Water Treatment Infrastructure SAMP

SPU has developed a strategic asset management plan (SAMP) for its water treatment facilities, including in-town disinfection facilities. This SAMP describes the infrastructure, their operations and maintenance, relevant service levels, repair and replacement needs, data needs, and other relevant asset information. Relevant information from the SAMP has been included in this chapter.

3.4 NEEDS, GAPS, AND ISSUES

In the past decades, 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 Water 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 revised total coliform rule, the radon rule, and revisions to the lead and copper rule. These future regulations and their expected impacts on SPU are summarized in Table 3-6.

As noted in Table 3-6, the proposed radon rule and the 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 3-6. Future Regulations and Impact on SPU

Regulation or Issue	Provisions	Impact or Consideration
Total Coliform Rule Revisions/ Distribution System Rule	Proposed rule would change the MCL for total coliform to a trigger level for follow up investigation and action. Other distribution water quality issues are further out on the regulatory horizon.	Existing SPU practices generally address the proposed approach regarding coliform.
Radon Rule	Proposed both an MCL of 300 pCi/L and Alternative MCL of 4,000 pCi/L. Proposal was made in 1999 with little known action since that time.	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.
Lead and Copper Rule: Long-Term Revisions	Likely to address lead service lines. Possible changes to optimal water quality parameters and sampling sites. May include schools.	Full impact of revisions not clear at this time. Some adjustment may be needed to monitoring plan and schedule. Lead service lines not used in Seattle.

3.4.2 Emerging Contaminants of Concern

Emerging contaminants are not regulated, they are generally new to drinking water scientists, and there is typically limited information about their occurrence and health effects. Understanding the significance of emerging contaminants can be difficult and complex given that lack of clear data. EPA takes on emerging contaminants primarily through the Contaminant Candidate List and the Unregulated Contaminant Monitoring Rule. In addition, SPU has made its own efforts in regard to some emerging contaminants in order to better understand the quality of SPU's water supply.

3.4.2.1 Contaminant Candidate List

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

The Safe Drinking Water Act directs EPA to publish a Contaminant Candidate List (CCL) every 5 years and EPA finalized the third list (CCL3) in 2009. It includes 104 chemicals or chemical groups and 12 microbiological contaminants. These contaminants occur or are anticipated to occur in public water systems. Contaminants on the CCL3 are not currently regulated and the list does not impose requirements on public water systems. EPA uses the list to prioritize research and data collection efforts to help determine if a contaminant should be regulated. Regulatory determinations must be made on at least 5 of the contaminants every 5 years.

Since SPU published its *2007 Water System Plan*, EPA determined in July 2008 that no regulatory action was necessary for eleven of the CCL2 contaminants, including the dacthal mono- and di-acid degradates, which had been detected previously at very low levels in the Riverton Wells. One microbial contaminant Mycobacterium Avium Complex (MAC) was listed on CCL2 and remains on CCL3.

Over the past several years endocrine disrupting chemicals (EDCs) and pharmaceuticals and personal care products (PPCPs) have been of concern nationally and are included on CCL3. EDCs and PPCPs include prescription 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 drinking water quality. More information on PPCPs is provided below.

The majority of the CCL3 contaminants present relatively low concern to SPU because of its excellent source protection practices, state-of-the-art water treatment facilities, and distribution system practices. SPU will continue to stay up to date on EPA regulatory determinations as well as participate in or stay informed on related studies and national occurrence of emerging contaminants.

3.4.2.2 Unregulated Contaminant Monitoring Rule

The Unregulated Contaminant Monitoring Rule (UCMR) is EPA's program for gathering public water system data on contaminants without current health based standards. Monitoring results are used for determination of future drinking water regulations. EPA requests or requires participation from a utility, depending on its size.

The UCMR monitoring rounds occur on a 5-year cycle, is largely based on the CCL, and the list may contain no more than 30 contaminants. SPU participated in UCMR 1 (conducted 2001-2005) and UCMR 2 (conducted 2007-2010). As a system serving more than 10,000 people, SPU and its wholesale customers are required to participate in UCMR 3 as well. The list of contaminants for UCMR 3 contains several categories of compounds that are unlikely to occur in our system given our protected source water. This includes seven hormones, six perfluorinated compounds, five metals, and seven VOCs.

For UCMR 3, SPU will collect quarterly samples at entries to the distribution system (treated Tolt and Cedar water) for a 12-month period sometime between 2013 and 2015. Distribution system samples are also required for UCMR 3 at the same frequency.

3.4.2.3 Chromium

SPU has routinely tested for total chromium (the combined total of chromium-0, chromium-3 and chromium-6) at the source and in the distribution system. In the past, SPU has not tested specifically for chromium-6, because there is no maximum contaminant level (MCL) for chromium-6, SPU's source waters have no adjacent industrial activities that would introduce chromium-6, and no reportable levels of total chromium have been found in SPU's water. The current MCL for total chromium is 100 ug/L. The naturally occurring background levels of total chromium in SPU's water range from non-detectable to 1.0 ug/L, with average results near our minimum detection limit (MDL) of 0.2 ug/L using EPA Method 200.8.

In March 2010, EPA announced that it had initiated a reassessment of chromium and published a draft human health assessment for chromium-6 in September 2010. The risk assessment should be finalized in 2011. On a related note, the California Office of Environmental Health Hazard Assessment (COEHHA) proposed a health goal for chromium-6 of 0.06 ug/L in August 2010 and subsequently proposed an even lower health goal of 0.02 ug/L on December 31, 2010.

Given the current level of review and discussion for potentially revising the chromium standard, EPA has provided guidance on voluntary, though strongly encouraged, monitoring for chromium-6. Recommendations included sampling quarterly at source and distribution locations currently sampled for Disinfection By-products Rule (DBP) Stage 1 and 2 testing. This would be approximately 8 quarterly samples for SPU.

With respect to testing, the standard method for total chromium analysis in drinking water has MDL's that are well above the potentially low-level (COEHHA) goal. The SPU laboratory MDL for total chromium using EPA Method 200.8 is 0.2 ug/L. EPA method 218.6 has a more sensitive detection limit and, depending on the laboratory, can measure chromium-6 at levels approaching 0.02 ug/L.

Based on SPU source water quality and lack of potential sources of chromium-6, the background total chromium level is presumably from naturally occurring chromium-3. It is possible for chromium-3 to convert to chromium-6 in treated drinking water depending on pH and disinfection treatment processes. To better quantify the low chromium levels in SPU's water, SPU began following the EPA recommended quarterly monitoring in 2011.

3.4.2.4 Pharmaceutical/Personal Care Products

Testing has confirmed the absence of PPCPs and EDCs in SPU's source water.

SPU conducted three rounds of testing in 2008 for pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) in our source water. Results confirmed the absence of PPCPs or EDCs in SPU's source water, which was not surprising considering SPU's exceptional source water protection efforts.

Prior to 2008, SPU conducted regulatory monitoring of its source water for synthetic organic compounds (SOCs) and for unregulated compounds, as part of UCMR 2. The sampling panels included some EDCs. Samples were collected from only the finished water for the Cedar and Tolt supplies. The analyses were conducted using a certified lab, following accepted field sampling procedures, and included QA/QC procedures. Historical results showed no detections of any suspected EDCs, including Atrazine, Butylbenzyl phthalate, Diazinon, Linuron, Methoxychlor, and bisphenol A.

Because prior UCMR testing did not include any PPCPs and samples were collected from locations following treatment, SPU conducted additional more extensive testing of source water and treated water beginning in April 2008. SPU conducted two rounds of sampling from Tolt and Cedar supplies at locations before and after treatment. SPU collected a third set of samples from Riverton and Boulevard Park wells in December 2008. SPU detected none of the PPPCPs and EDCs tested.

3.4.3 Kerriston Road in the Cedar River Watershed

Kerriston Road is a King County road that has more than two miles lying within the hydrographic boundary of the Cedar River watershed in the vicinity of Brew Hill. The road provides the only existing access to 322 acres of privately-owned property located outside of the municipal watershed hydrographic boundary. WDOH has expressed concern about the potential public health and water quality impacts that could result from public use of the road. The 2009 acquisition of the 4,000 acres by King County and the Washington Department of Natural Resources in the Raging River area reduced the total area of privately-owned property accessed by the Kerriston Road by 84 percent, significantly reducing the scale of the potential future development threat and investment to acquire remaining properties. In 2008 SPU conducted a feasibility study and cost estimates for acquiring the private properties accessed by the Kerriston Road. A portion of the property, about 148 acres, has been purchased. Before proceeding with further acquisitions, SPU is conducting a risk-cost analysis of public access on the Kerriston Road to determine if additional land acquisition is the preferred approach for mitigating risk.

3.4.4 Lake Youngs Water Quality

Lake Youngs is a high quality, oligotrophic lake, meaning it has low nutrient content and low biological productivity. In recent years, SPU has observed some changes in Lake Youngs' water quality, particularly some new dominant algal species and less predictability in the timing of algal blooms. SPU held a workshop of limnology experts in 2009 to look more closely at the water quality data and determine if these changes in algae are indicative of more fundamental or permanent changes in the lake. The expert panel concluded that the types of changes observed are well within normal ranges and do not suggest any significant degradation of the lake.

Algal blooms have been observed in Lake Youngs since the 1920s. Prior to the startup of the Cedar Water Treatment Facility, these algal blooms would cause undesirable tastes and odors in the drinking water. The new treatment facility has eliminated nearly all these effects. Another effect of algae has been that over time it can accumulate on water filters used in homes and businesses. One of the new dominant types of algae in the lake, *Cyclotella*, has been found to produce fine filaments that not only clog filters, but accumulate on screens used in the water system. Because of the more problematic nature of these filaments, SPU strives to avoid this algae by bypassing Lake Youngs during a bloom.

SPU has an extensive lake monitoring program. In response to the changes in the lake and recommendations of the expert panel, SPU has added to that program in order to better characterize the lake. Water quality monitoring has been improved with the addition of some sampling and the installation of a remote floating water quality monitoring station on the lake. A water quality modeling effort has also been taken on in order to better understand the lake and to look at the impacts of operational changes and potential improvement projects.

3.4.5 Aquatic Nuisance and Invasive Species

Several aquatic organisms currently create or have the potential to create nuisance conditions in Washington state waters, including SPU's drinking water supplies. Once established in an aquatic system, infestations of these nuisance organisms can be difficult to control and impossible to eradicate, resulting in deleterious effects on water quality and water system operations.

Several aquatic nuisance species are specific targets of SPU's prevention program because of their proximity to the Cedar River, ease of invasion, or significance of impact. The invasive aquatic plant species include: *Eurasian milfoil*, parrotfeather, *Hydrilla*, *Brazilian elodea*, fanwort, water hyacinth, and others. The microorganism species include *Didymosphenia geminate* (didymo), Whirling Disease, and others. The animal species include the zebra mussel, quagga mussel, New Zealand mud snail (NZMS), Chinese mitten crab, and others. All of the aquatic nuisance plant species listed here have been positively documented in freshwaters of Washington State, including NZMS in Seattle's Thorton Creek.

SPU's "Prevention of Aquatic Nuisance Species Plan" outlines general responsibilities of field personnel working in any of the water supply reservoirs and watersheds. A detailed equipment decontamination procedure is included in the plan. In addition to preventing the introduction of aquatic nuisance species, the decontamination procedure is designed to prevent contamination by any biological organism (i.e., plant, animal, or microbe) that is either a native or exotic species and may be terrestrial or aquatic in origin, and by any chemical or petroleum product.

3.5 IMPLEMENTATION/ACTION PLAN

With the construction of four new buried reservoirs to replace the pre-existing Beacon, Myrtle, West Seattle, and Maple Leaf open reservoirs, SPU has accomplished a great deal since the *2007 Water System Plan*. These actions have supported SPU in 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 a list of important upcoming projects and actions in the Water Quality and Treatment business area that include the following:

- Remove Roosevelt and Volunteer Reservoirs from service following the completion of the Maple Leaf reservoir burying project. Evaluate water system operation without Roosevelt and Volunteer Reservoirs and confirm a decision on how to go about the decommissioning of Roosevelt and whether to decommission or cover Volunteer Reservoir.

- In about 2020, evaluate options for replacing the floating covers at Bitter Lake and Lake Forest Park Reservoirs, given that the covers at these sites will reach the end of their useful life within the next 10 to 15 years

- Complete the conversion from chlorine gas to sodium hypochlorite at Landsburg.

- Evaluate contract extension options for the Tolt and Cedar Water Treatment Facilities.

- Review distribution system flushing practices and the level of resources allocated to flushing.

- 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.

- Conduct a risk-cost analysis of public access on the Kerriston Road to determine if additional land acquisition is the preferred approach for mitigating the risk of impairing Cedar source water quality.

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

- Bypass Lake Youngs to avoid problematic algae from entering the water system.

- Continue efforts to prevent aquatic nuisance and invasive species from being introduced into SPU's drinking water supplies.

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Chapter 4
Water Transmission System

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 consists of both regional and sub-regional facilities, as defined in the wholesale water contracts.

4.1 Accomplishments Since 2007 WSP

Since completion of the *2007 Water System Plan,* SPU has implemented the following improvements to the water transmission system:

- Control Works Surge Tanks: Installed painted, welded mild steel structural covers on these tanks to protect drinking water quality (2010).

- Lake Youngs Supply Lines Standpipes: Extended open air standpipe air vents to prevent or reduce occasional overflows when Lake Youngs is bypassed (gravity operation from Landsburg to Cedar Treatment).

- Cedar/Tolt Transfer Improvements: In Seattle, installed a modulating valve at Maple Leaf Gatehouse to allow the Tolt source to supply farther south into areas normally supplied from the Cedar source. On the Eastside (Woodinville), upgraded the diesel backup pump at TESS Junction that delivers Cedar water into the upper reaches of Tolt Pipeline No. 1 at times of Tolt source outage (2010).

- Cedar River Pipeline Improvements and Upgrades:

    - Slip-lined portions of Cedar River Pipeline 4 (CRPL4) where it crosses I-405 in Tukwila and protected the segment of CRPL4 where it crosses SR-167 in Renton to prevent this major transmission pipeline from potential damage during widening of both highways by the State of Washington, as well as to extend its useful life (2010).

  - Completed a sonic leakage test of Cedar River Pipeline 2 from Volunteer Reservoir to Maple Leaf Reservoir (also known as the 430 Pipeline) using "smart ball" technology to assess its condition and found no leaks (2007).
  - Improved the supports under above-ground sections of Cedar River Pipelines 1, 2, and 3 in Tiffany Park in Renton to increase the likelihood of the pipelines remaining operational after a larger earthquake.
  - Replaced sections of Cedar River Pipelines 1, 2 and 3 where they cross the Sound Transit Light Rail at Martin Luther King Way in Seattle, to protect these transmission pipelines.

- Cathodic Protection Program: Installed cathodic protection on a concrete cylinder pipe section of CRPL4 near South Center in conjunction with the I-405 widening improvements discussed above.

- Tolt Slide Monitoring: After ground movement in 2009 and subsequently finding that Tolt Pipelines No. 1 and No. 2 both cross an ancient slide located between the Regulating Basin and Tolt Water Treatment Facility, installed a 48-inch double ball joint expansion sleeve on TPL2 to allow the pipeline to better conform to the creeping slide. Also initiated an on-going survey and inclinometer monitoring program to monitor slide movement.

- Wholesale Customer Meters: Added several new wholesale services as requested by its whole sale customers primarily to improve retail service reliability within the wholesale customers' service areas.

In addition, Maple Leaf and West Seattle Reservoirs, which are part of the transmission system, were replaced with buried reinforced concrete tanks as described in Part I, Chapter 3.

4.2 Service Level Performance

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 service to wholesale customers.	• Meet wholesale contract requirements for pressure and flow. • 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).

These service level targets have been met since 2006. SPU's wholesale contracts require SPU to provide a minimum pressure and maximum flow rate at each wholesale service connection, with contingencies for emergency or unusual conditions. There have been no contractual compliance issues in recent years. Additionally, there have been no unplanned outages of the transmission pipelines that have exceeded SPU's service level for maximum outage durations.

4.3 EXISTING SYSTEM AND PRACTICES

SPU's regional and sub-regional water transmission systems include 193 miles of pipeline, 7 covered reservoirs, 15 pump stations, 6 elevated tanks and standpipes, and 129 wholesale customer taps with meters.

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.

4.3.1 Existing Infrastructure

The regional and sub-regional water transmission systems include approximately 193 miles of pipeline, seven 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 129 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. Inventories of the primary transmission system facilities are provided in the appendices.

4.3.1.1 Pipelines

SPU's transmission system contains approximately 193 miles of large-diameter pipelines. These pipelines convey untreated water from the supply sources to the treatment facilities and treated water from the treatment facilities to the wholesale and retail service areas. These pipes vary in size from 16 to 96 inches in diameter, with some connections and bypasses being smaller. The bulk of these pipelines are made of steel and concrete, with a small portion consisting of ductile or cast iron, as shown in Figure 4-1.

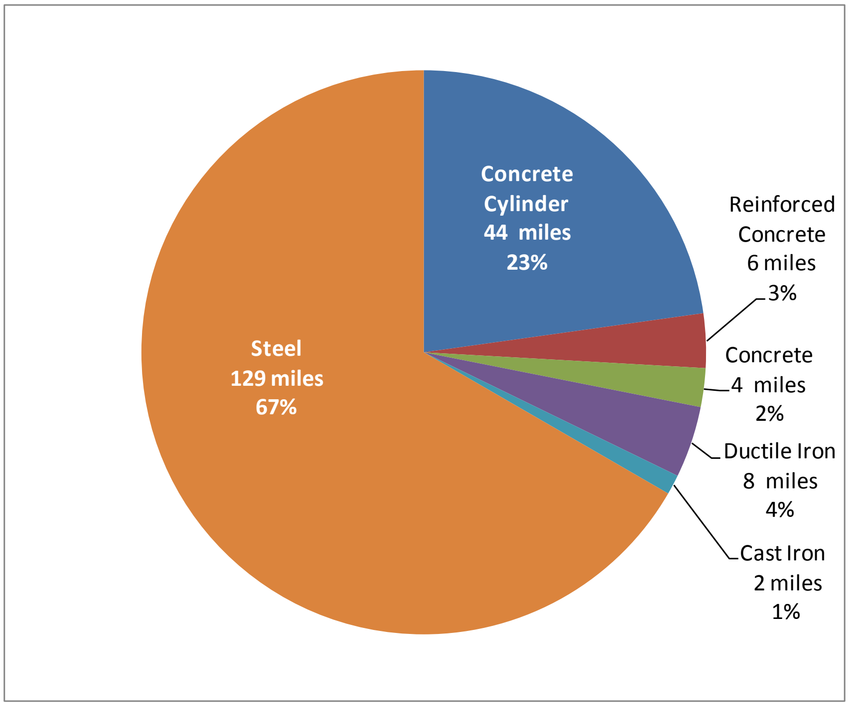

Figure 4-1 Breakdown of Transmission Pipeline Material

SPU relies on the leakage history and visual inspections 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.

4.3.1.2 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. With completion of the Maple Leaf and West Seattle reservoir burying projects in 2010, all seven of SPU's treated transmission system reservoirs are covered. With the exception of Lake Forest Park Reservoir, these reservoirs are pre-stressed or reinforced concrete tanks. 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 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. When evaluating leakage rates, SPU looks for increasing trends and anomalies that could indicate deteriorating conditions at the reservoir. 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 conducted since 2005 reveal that the storage reservoirs are in good condition. The leakage rates from Soos North and Soos South Reservoirs are low, 0.11 gallons per minute per million gallons (gpm/MG) and 0.04 gpm/MG, respectively, when tested in 2006-2007. Riverton Heights Reservoir was last tested in 2007 and had negligible leakage. The leakage rates for Lake Forest Park and Eastside Reservoirs are 1 and 2 gpm/MG, respectively, which has been typical for these reservoirs since 1994.

In 2008 and 2009, a detailed condition assessment was performed by a consultant for the Eastside Reservoir, and its inlet-outlet pipeline up to its connection to the Tolt Eastside Supply Line at SE 16th Street in Bellevue. The effort was intended to provide information to the Cascade Water Alliance on the condition of these facilities for a possible acquisition. The work included inspection of the pre-tensioning wire of the reservoir, internal inspection of the pipeline at two locations, and soil corrosivity assessment along the pipeline. Both the reservoir and the pipeline were found to be in good condition; however, Cascade has since decided not to pursue acquisition of these facilities for other reasons.

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 0.3 to 2 MG. Richmond Highlands #1

Tank and Foy Standpipe are to be removed from service and decommissioned. Decommissioning of Myrtle #1 Tank is also proposed, but approval by WDOH is pending. More information on system performance without these facilities is provided in the appendix on System Storage Level of Reliability.

Tanks, including standpipes, are expected to have a service life of approximately 100 years with regular maintenance. SPU inspects the tanks visually to evaluate their condition and appearance. Structural inspections are conducted when tanks are drained for cleaning. Exterior sanitary inspections are conducted quarterly. The condition of the tanks is evaluated for the condition of interior and exterior coatings, as well as its valves and pipes. The condition of each tank varies, depending on its year of construction and the year the last interior and exterior coatings were applied.

SPU has an on-going tank and standpipe recoating program. The program involves safety modifications at tank sites, minor structural repairs, and interior and exterior surface preparation and coating following a regular maintenance cycle. Tank painting generally follows an approximate 20-25 year cycle. The timing will vary with need as shown by inspections and economic analysis. Myrtle Tank #2 was recoated in 2010, and Richmond Highlands Tank #2 is scheduled for recoating in 2012.

4.3.1.3 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 was the upgrade of the diesel pump at the Tolt Eastside Supply (TESS) Junction Pump Station to provide for improved delivery of water from the Cedar system to the upper reaches of TPL1 and the Tolt Water Treatment Facility clearwells in the event of a Tolt source outage.

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. Recently, SPU has begun implementing a Reliability Centered Maintenance (RCM) program for its pump stations, which is described more fully in Section 4.3.3.3. Since it will take several years to complete RCM on all active pump stations, the current practice is to determine replacement/upgrade schedules according to the expertise of SPU Maintenance Division staff. Pumps are monitored for efficiency and overhauled every 5 to 7 years.

4.3.2 Operations

Since completion of the Cedar Water Treatment Facility in 2004, water from the Cedar source 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 former Lake Youngs Bypass No. 4 pipeline. FWP No. 5 and FCF No. 5 deliver water to the Lake Youngs tunnel through the former Lake Youngs Bypass No. 5 pipeline. From the Control Works, water flows to the four Cedar River Pipelines (CRPLs) 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 Water Treatment Facility clearwells through the Cedar River pipelines, but flow is constrained by the Cedar Water Treatment Facility treatment capacity of 180 mgd.

How long does it take the water to get to my house?

It typically takes about two weeks for the water to get from the treatment plants to your faucet.

For the Tolt source, raw water is delivered from the South Fork Tolt Reservoir to the Regulating Basin either through the original South Fork Tolt Pipeline or through the Seattle City Light penstock pipeline installed in 1995. From the Regulating Basin, which serves as a break in the hydraulic grade line and as regulating storage for hydropower production, the raw water moves through a screenhouse and then into Tolt Pipelines Nos. 1 and 2 to the inlet of the Tolt Water Treatment Facility. Treated water from the clearwells of the Tolt Water Treatment Facility flows west in the original and, in some places, replaced Tolt Pipeline No. 1 (TPL1) to the Duvall area where TPL1 bifurcates into TPL1 and Tolt Pipeline No. 2 (TPL2). TPL2 follows a separate southwesterly alignment and connects to the Tolt Eastside Supply Line in Kirkland. TPL1 runs west and connects to the north end of the Tolt Eastside Supply Line (TESSL) in Woodinville. West from the Woodinville area TPL1 and TPL2 follow the same original right-of-way to Lake Forest Park Reservoir. TPL2 is in active mode along this stretch whereas TPL1 is in standby mode at lower pressure. TPL1 is kept fresh by maintaining a low level continuous discharge directly into Lake Forest Park Reservoir whereas the main supply to the reservoir comes from TPL2. 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.

SPU has performed extensive hydraulic modeling analysis, and has implemented capital improvements to reduce the likelihood of water service interruption in case of unplanned source outage. As a result, the SPU system is expected to be able to meet indoor and off-peak season water use of the entire service area, most likely including the wholesale customer demand, for at least seven days with only one of its two main sources available. In case of an unexpected source outage during higher demand periods, SPU plans to reduce water demand to indoor levels through aggressive public messaging in the media. More information on system performance under these scenarios is provided in the appendix on System Storage and Reliability Standard. Such responses to emergency outages are covered in the Water Shortage Contingency Plan contained in the *2007 Water System Plan*.

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.

4.3.3.1 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 typically performed only when opportunities present themselves, such as when a pipeline is exposed for other work. However, since the *2007 Water System Plan*, SPU performed five dig-up inspections on Cedar River Pipeline No. 4, a reinforced concrete pipeline, to confirm that it was in good structural condition. Earlier, dig-up inspections were done on the Tolt Pipeline between the Tolt Water Treatment Facility and Kelly Road where the original 66-inch concrete cylinder pipe is still in service.

4.3.3.2 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, as evidenced by regular water quality monitoring. The cleaning schedule is explained in the Water Quality and Treatment chapter.

4.3.3.3 Pump Stations

In 2007, SPU piloted a Reliability Centered Maintenance (RCM) program and brought in a consultant to train in-house staff. RCM is a major shift from traditional maintenance programs that primarily apply time-based maintenance on system components, in this case, components of pump stations. Instead, RCM focuses on the function, failure mode, and criticality of a component to determine the frequency and type (i.e., preventive, predictive, or corrective) of maintenance to perform.

SPU adopted RCM as the core of our maintenance program and has analyzed Burien Pump Station and implemented changes to maintenance tasks and frequency in Maximo (SPU's computerized maintenance management system).

Maintenance activities at water pump stations ensure that the stations continue to operate with minimal loss of function, 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.

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	Annually
Electrician	Valve operator	Annually
Mechanics	Overhaul pressure regulator	2 to 5 years
Mechanics	Flow meter inspect/overhaul	2 to 5 years
Mechanics	Diesel engine exercising	Every 2 months
Mechanics	HVAC filter change	Every 2 to 3 months
Mechanics	Air conditioner inspection	Annually
Mechanics	Pump station check	Weekly
Grounds	Basic site check	Weekly

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.

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.

4.3.3.4 Wholesale Customer Meters

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

SPU owns and maintains 129 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 *2007 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 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. SPU's approach to field testing of wholesale meters varies with the type of the meter. There are three types of meters: compound, turbine and electronic. Typically, compound meters are field tested annually. Based on operational experience, SPU recently extended the period between tests for turbine meters to once every three years. First, the measuring element is replaced in the field with a measuring element that has been bench tested and known to be accurate. The removed measuring element is then tested on the bench, and repaired as needed. Electronic meters, which are mostly magnetic flow meters, are tested once a year for accuracy of the zero set point and for other applicable electronic settings; due to their size they cannot be typically tested by the conventional method of flowing water and comparing to a reference meter.

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. Typically maintenance is performed at the time of testing.

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. 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 identified several needs, gaps, and issues in regards to the transmission system. Needs include mitigating the risk of pipeline failure in the Tolt slide area and extending the life of transmission pipe using cathodic protection. The following subsections summarize these issues and SPU's approach to addressing them.

4.4.1 Tolt Slide Monitoring

In 2009, Tolt Pipelines 1 and 2 were found to cross a historic slide located between the Regulating Basin and Tolt Water Treatment Facility. The slide had been dormant, and therefore unknown, since the pipelines were installed in the 1960s and late 1990s, but has become more active apparently due to a combination of logging in upland area and erosion by the North Fork Tolt River. This slope movement has affected both pipelines: the ground in the vicinity of TPL2 has moved up to 6 inches, or about 3 inches per year, and near TPL1 it is about one-half of that rate. Since discovery of the slide, TPL1 has been kept empty most of the time to reduce the risk of new small joint leaks triggered by the ground movement and aggravating slope stability. A 48-inch double ball joint expansion sleeve was installed on the newer steel TPL2 to allow the pipeline to better conform to the creeping slide. The ball joint can elongate up to 18 inches, and has moved about 0.8 inches since installation. In addition, SPU initiated an on-going survey and inclinometer monitoring program to track the slide and pipeline movement.

SPU plans on performing the following analysis and actions to gain a better understanding of the situation and mitigate the risk of pipeline failure:

- Continue to collect geotechnical data to better understand the causes behind ground movement.
- Acquire ownership of the slide area to preclude future logging and deforestation, and to gradually reduce the water load on the slide through re-vegetation.
- Perform periodic internal inspections of the Tolt pipelines when monitoring indicates possible stress buildup at certain locations, and implement stress relief measures when necessary, such as cutting and re-welding the pipe, and/or installing additional expansion couplings.
- Perform biannual leak testing of Tolt Pipeline No. 1 to monitor for new small joint leaks that would further aggravate slope stability.
- If and when necessary, implement stress relief or other measures to mitigate the risk of pipe failure.

4.4.2 Cathodic Protection Program

Cathodic protection is a method used to minimize the rate of electrochemical corrosion of metallic materials, such as pipes, by shifting the corrosion process away from the metal to be protected and onto other more easily corroded "sacrificial" pieces of metal.

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 and repairable well before catastrophic failure.

Failure issues associated with each type of pipeline differ because of their different failure modes and risks. Cathodic protection systems have been shown to extend the life of pipe and reduce the risk of failures for both types of pipes, as described below.

4.4.2.1 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 slight tension. The entire exterior is then coated with concrete mortar to provide additional stiffness and corrosion protection. CCP derives its strength from the combined strength of the steel cylinder and the pretensioned rod reinforcing. However, 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 due to pipe deterioration occurred in 1987 on the 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 through dig-up inspections revealed some deterioration of the rest of the CCP lines but that these lines are still in 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 one to three miles of concrete cylinder pipe with fairly even electric potential distribution.

The likelihood of catastrophic failure varies across pipeline sections. In some places the steel cylinder is thick enough to withstand normal working pressure even if the entire rod corrodes away. SPU is in the process of developing a comprehensive strategy to identify where it would be cost-effective to install cathodic protection. Cost effectiveness is generally defined as the avoided risk costs being higher than the costs to install and operate a cathodic protection system. Pipeline segments that are likely to fail catastrophically, and are located in urban areas where consequences of failure would be significant, are likely to qualify for cathodic protection installation.

In addition to the cathodic protection program, SPU plans to reduce of risks of failure in its CCP lines using the following strategies, which were identified in the *2007 Water System Plan*:

- 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.

4.4.2.2 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. 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.

4.5 IMPLEMENTATION/ACTION PLAN

As described earlier, the primary issues facing the transmission system include mitigating risks in the Tolt slide area and extending the life of existing pipelines through continued deployment of cost-effective cathodic protection systems, especially for concrete cylinder pipe. To address those and other issues discussed in this chapter, SPU has identified the following major implementation and action plan items:

- Mitigate the risk of pipe failure in the Tolt slide area through continued slope monitoring, geotechnical data collection, periodic internal inspections, and biannual leak testing, and by taking such actions as acquiring ownership of the slide area and implementing stress relief measures when necessary.

- Continue to implement cost-effective cathodic protection projects for the concrete cylinder and steel transmission pipelines to protect these from corrosion and extend their service lives well into the future.

- Continue to operate the regional water system and manage outage durations for transmission pipelines to meet service level targets.

- Decommission Foy Standpipe and Richmond Highlands Tank #1, as well as Myrtle #1 Tank if approved by WDOH.

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Chapter 5
Water Distribution System

This chapter focuses on the SPU water distribution system, the business area that involves delivery of water for retail use and for fire flow. SPU's water distribution system consists of watermains, 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 Accomplishments Since 2007 WSP

Since completion of the *2007 Water System Plan,* SPU has implemented the following improvements to the water distribution system:

- Pressure Improvements: Completed improvements to raise pressure in areas where services had less than 20 psi on Queen Anne Hill, in the lower Queen Anne 326 pressure zone, and in the Maple Leaf 530 pressure zone (2009).

- Queen Anne Pipe Replacement: Replaced watermain to withstand increased pressure associated with the new Queen Anne tank and pump station projects (2008).

- Backbone Pipeline System Seismic Upgrades:
  - Upgraded the seismic backbone along South Spokane Street from west of 1st Ave South to the Burlington Railroad tracks just east of Airport Way South.
  - Upgraded the seismic backbone along 1st Avenue South between South Stacy Street and South Spokane Street.

- New Taps: Installed over 5,300 new customer taps from 2007 through 2010.

- Service Renewals: Renewed or replaced over 3,400 services, primarily those made of plastic tubing, from 2007 through 2010.

- Water system improvements and watermain replacement associated with third-party projects:
    - Hidden Lakes Combined Sewer Overflow Betterments: Replaced approximately 1,100 feet of sub-standard watermain and associated fire hydrants to improve fire flow in the Shoreline service area (2007).
    - State Highway 99 (Aurora Avenue): Made various water system improvements along this highway between 145th Street to 192nd Street in the City of Shoreline.
- Steel Tank Recoating: Recoated Myrtle Tank #2 (2010).
- Tank Decommissioning: Decommissioned, but did not demolish, Maple Leaf Tank and Woodland Park Standpipe based on asset management business cases and to avoid the costs needed to upgrade the facilities (2009).

Additionally, Beacon and Myrtle Reservoirs, which are part of the distribution system, were replaced with below-grade reinforced concrete tanks, as described in Part I, Chapter 3.

5.2 SERVICE LEVEL PERFORMANCE

SPU consistently responds to reported distribution system problems within one hour more than 90 percent of the time.

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 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.

SPU has been meeting these service level targets. Since completion of the pressure improvement projects in early 2009, pressures at all retail service connections are greater than 20 pounds per square inch (psi) during normal operations. SPU also designs new or expanded parts of the distribution system to deliver a minimum of 30 psi during peak hour demand.

For each year since 2006, SPU consistently responded to reported distribution system problems within one hour more than 90 percent of the time. Because of this high level of performance, SPU raised the service level target in 2009 to 90 percent from the minimum of 80 percent that was documented in the *2007 Water System Plan*.

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.	• 90 percent 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 percent of total supplied, as defined by Washington Department of Health guidelines.

Distribution system leakage (DSL) has been reported to WDOH since 2006, as required by the 2003 Municipal Water Law (WAC 246-290-820). By definition, DSL is the difference between the total amount of water produced and the amount authorized for consumption. DSL includes water lost from pipe and service line breaks, as well as from storage facilities. It also includes metering inaccuracies and unauthorized uses. Due to the location of SPU's meters, losses in the transmission system are included in the reported DSL figures.

SPU's estimate of authorized consumption consists of water sold to retail and wholesale customers based on metering data, and estimates of water used to drain and clean treated water storage reservoirs and in overflowing of open reservoirs for water quality management. Small amounts of water used for authorized purposes such as firefighting, hydrant testing, watermain flushing, sample stand usage, and permitted hydrant usage (e.g., for building construction) have not been included in the estimate of authorized consumption because it would be costly to meter the use, compute an estimate, or determine the amount used in a calendar year. Exclusion of these authorized uses increases the amount of reported distribution system leakage. As shown in Figure 5-1, SPU's DSL has increased from less than 3 percent in 2006 and 2007 to more than 6 percent in 2010 and 2011. However, the 3-year rolling average has remained below the WDOH standard of 10 percent.

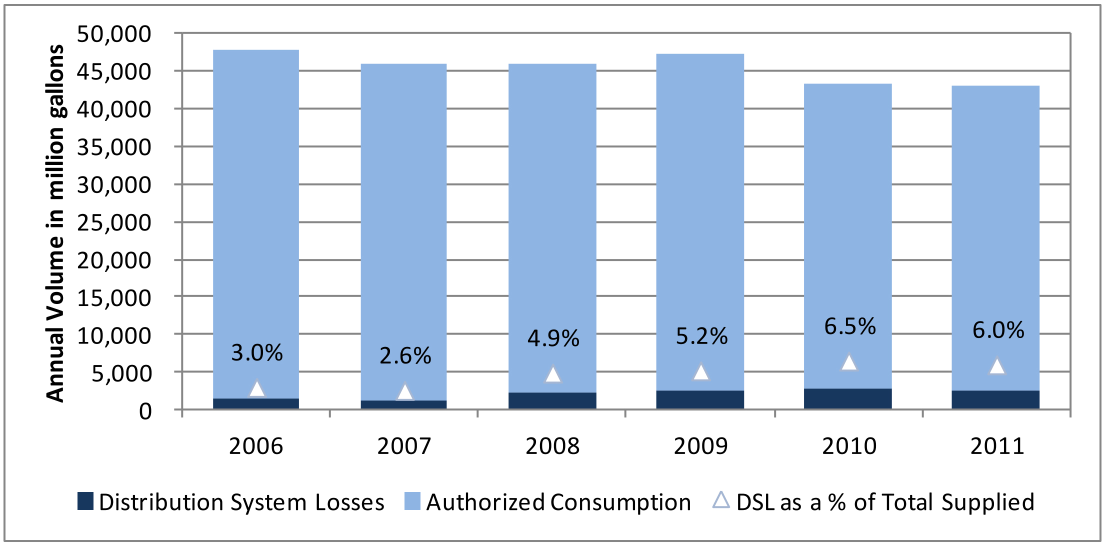

Figure 5-1. Distribution System Leakage

5.3 Existing System and Practices

SPU's distribution system contains more than 1,680 miles of watermains, 2 open reservoirs, 6 covered reservoirs, 16 pump stations, 6 elevated tanks and standpipes, 21,000 valves, and 18,920 fire hydrants, as well as more than 188,000 retail service connections.

The water distribution system consists of the facilities that deliver treated water to SPU's retail water customers. Distribution system facilities include watermains, storage facilities, pump stations, retail customer meters, and other appurtenances. The water distribution system contains more than 1,680 miles of watermains, most of them 6 to 12 inches in diameter. Seattle's water distribution system also includes two open reservoirs, six covered reservoirs, 16 pump stations, and six elevated tanks and standpipes. In addition, the City has more than 21,000 valves, 18,920 fire hydrants and 188,000 service lines and meters serving individual residential and non-residential properties.

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 *2007 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.

5.3.1.1 Watermains

Seattle owns a network of more than 1,680 miles of watermains within its retail service area. Since the *2007 Water System Plan*, many watermain improvement projects have been completed, with a number completed in conjunction with re-development and other agency projects, such as transportation projects within the City limits and in Shoreline. However, the overall configuration of the distribution system remains unchanged since 2007.

The condition of SPU's watermains 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 year of installation by decade and material type of distribution watermains is shown in Figure 5-2. Mainly unlined cast iron pipe was installed through the 1930s, followed by lined cast iron pipe. Since the 1970s, ductile iron pipe has been installed in almost all instances.

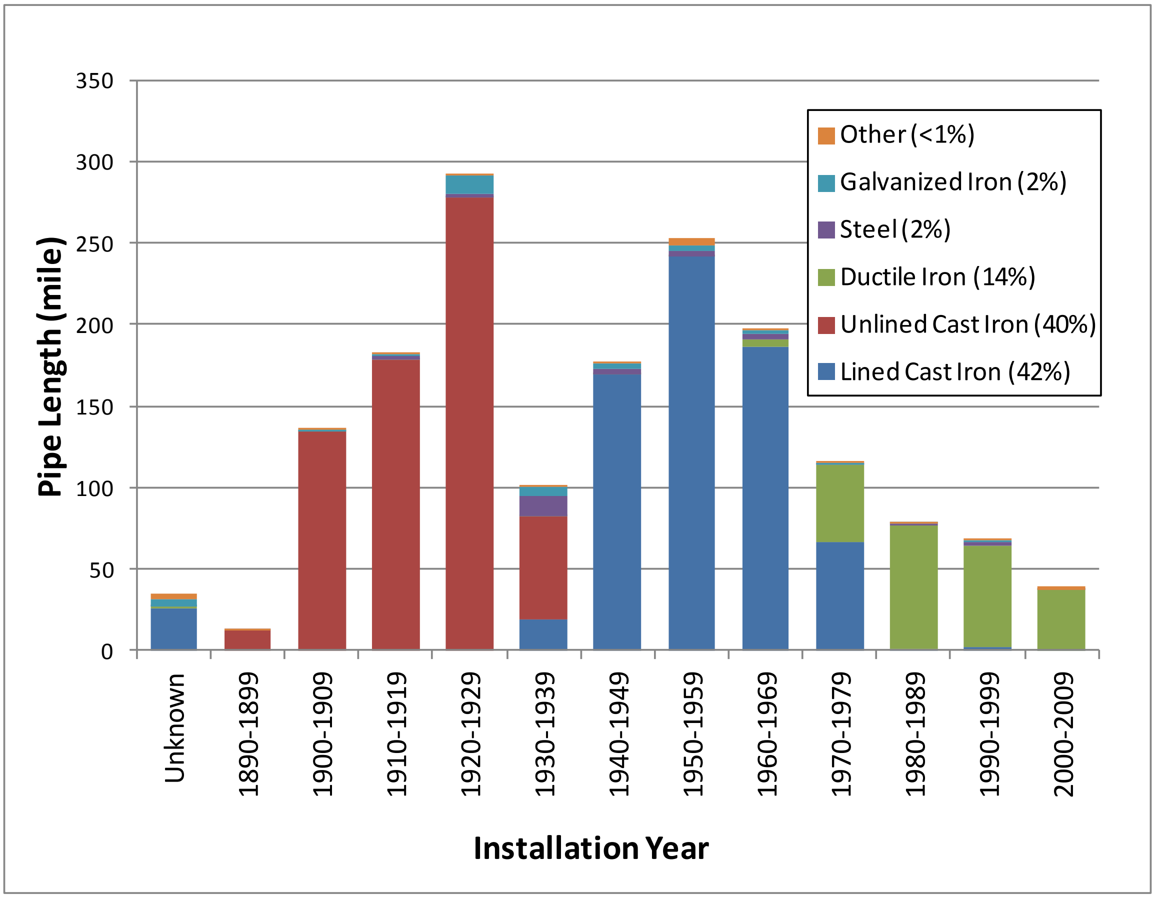

Figure 5-2. Type of Material and Decade of Installation for SPU's Distribution System Watermains

Currently, cast iron pipe is the most common type of pipe material used in SPU's distribution system. More than 80 percent of the pipes are cast iron, with roughly one-half of that unlined and one-half lined. Ductile iron pipe, the current standard and most common pipe material installed since the 1970s, is the third largest material type, at 14 percent. Galvanized iron and steel each make up about 2 percent of the system. The remaining pipe is made of other materials, including concrete cylinder (0.3 percent), polyvinylchloride (plastic) (0.2 percent), copper (0.1 percent), and kalamein (a type of steel) (0.1 percent). There is no asbestos pipe in the system. Figure 5-3 provides a breakdown of material types by pipe size. As indicated by the figure, the majority of pipe, or approximately 61 percent, is 8 to 10 inches in diameter.

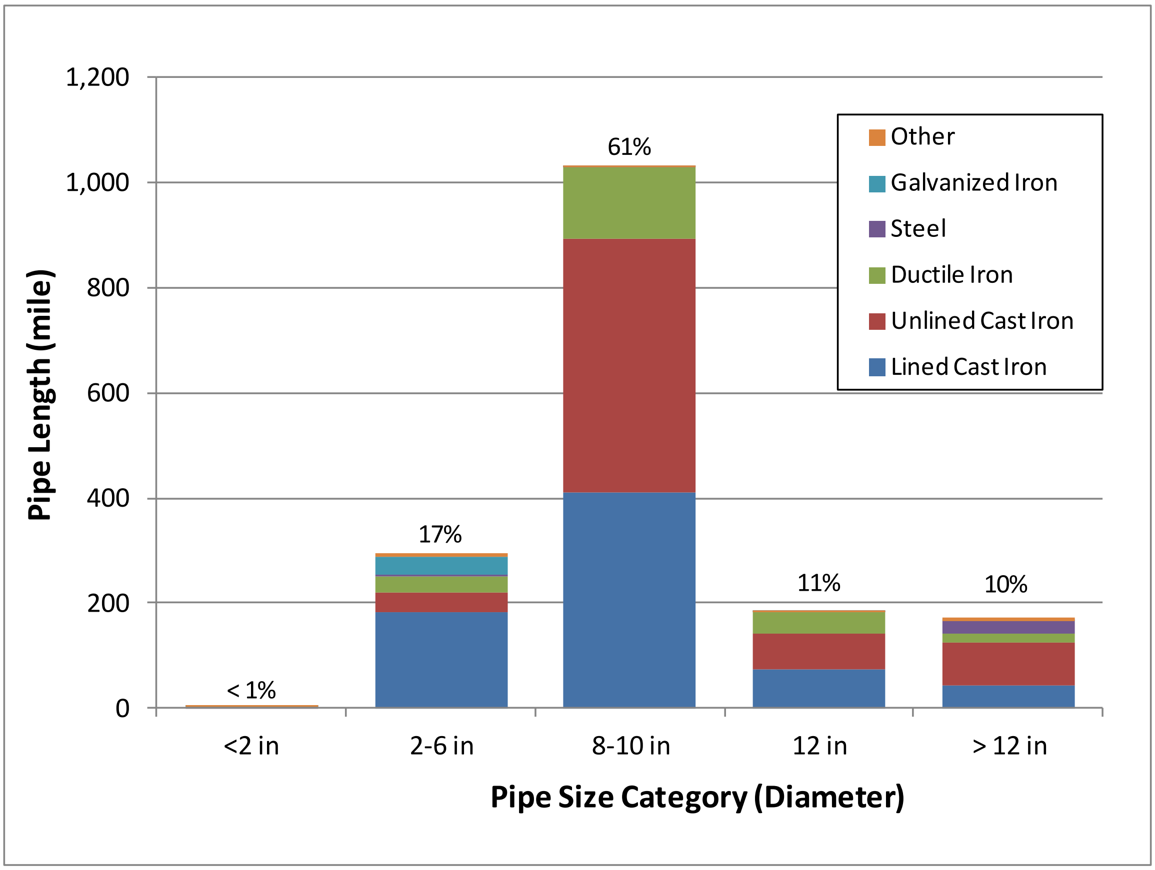

Figure 5-3. Pipe Diameter and Material Types for SPU's Distribution System Watermains

SPU does not have specific condition assessment information for most of the distribution system watermains. Although inspections are performed following watermain leaks and breaks, or when the watermain is exposed by potholing or adjacent construction, additional condition assessment activities are planned in the near term. Without specific condition assessment data, the most appropriate measure of condition of the watermains is the pipe material, soil type, age and number and types of leaks and breaks. Based on data from 2004 through 2010, the rate of watermain leaks and breaks remains low, averaging less than 10 reported leaks or breaks per 100 miles per year in the distribution system. This is less than the rate experienced by other major water utilities in the United States[1]. SPU's approach to replacing and rehabilitating watermains is described in Section 5.4.

Not all leaks or breaks require water service delivery outages. However, if a repair does require an outage, it is considered unplanned. Distribution system improvement projects can lead to planned or scheduled outages. From 2006 through 2010, approximately one-half of all outage events were unplanned, and one-half were planned. During this period, fewer than 2 percent of all customers experienced water service delivery outages of more than 4 hours per year from all planned or unplanned events.

5.3.1.2 Distribution System Water Storage Facilities

SPU's distribution system includes eight in-city reservoirs and six elevated tanks and standpipes to provide operating and standby storage capacity to its retail customers. The amount of storage provided is explained more fully in the appendix on System Storage Level of Reliability.

Distribution System Reservoirs. The City of Seattle owns and SPU operates and maintains eight reservoirs in the distribution system. The Myrtle and Beacon reservoir replacement projects were completed and placed in service in mid-2008 and early 2009, respectively. SPU is investigating the possibility of retiring the last two open reservoirs, Volunteer and Roosevelt, as noted in Chapter 3.

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. When last tested in 2009, the leakage rate at Magnolia Reservoir was negligible. The leakage rate from Volunteer Reservoir was 0.9 gallons per minute per million gallons (gpm/MG) in 2011. View Ridge Reservoir leakage was measured to be 2.9 gpm/MG in 2005. The leakage rates from Bitter Lake and Roosevelt Reservoirs were low and estimated to be 0.82 and 0.04 gpm/MG, respectively, when tested in 2009.

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[1] Neil S. Grigg, 2007, *Main Break Prediction, Prevention, and Control*. Report 91165. AwwaRF and AWWA.

Distribution System Elevated Tanks and Standpipes. In addition to its in-town reservoirs, the SPU water distribution system includes one elevated tank and five standpipes. The elevated tanks and standpipes were constructed between 1907 and 2008. They range in capacity from 0.9 mg to 1.9 mg. Maple Leaf Tank and Woodland Park Standpipe have been decommissioned but not demolished. In addition, Barton Standpipe is planned to be decommissioned in 2012 after its bypass is completed. Trenton Standpipes and Volunteer Park Standpipe are also being considered for decommissioning. The appendix on System Storage Level of Reliability provides more information on the approach used to analyze the system without these facilities.

Distribution system tanks and standpipes are inspected and maintained in the same manner as transmission system tanks, as described in Chapter 4.

5.3.1.3 Distribution System Pump Stations

SPU operates 16 distribution system pump stations with a total of 36 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 is the addition of a new pump station on Queen Anne Hill to address low-pressure problems experienced by customers. An 8-inch pressure regulating valve (PRV) and bypass line were installed at the View Ridge Pump Station to allow water to recirculate through the reservoir and prevent over-pressurizing the 550 pressure zone, if the connection to the pressure relief at Roosevelt Way Pump Station is out of service.

One change planned for the pump stations is to retrofit the permanent stand-by diesel pump at Bitter Lake Pump Station with remote-manual start capability. This change will allow the pump to be started from the Operations Control Center to supply the 590 pressure zone in the event of a power outage. After this change is implemented, Richmond Highlands #1 Tank, which serves the northwest sub-regional system, will no longer be needed to supply the zone and could be decommissioned.

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

5.3.1.4 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 line valves exist to reconfigure the flow of water through the distribution system as needed, while other valves regulate pressure and flow, provide for bypassing of facilities, or allow air to escape the system. Most valves within the distribution system are gate valves.

SPU asset management approach focuses attention on assessing the condition of critical valves and conducting preventative maintenance or corrective repairs, based on condition. For non-critical valves (valves that isolate flow on non-critical watermains discussed in Section 5.4.1.1), repairs are initiated as needed when defects are noted during valve operation. Valve replacement is initiated when the repair or resolution of a defective condition is impossible, or would cost more than valve replacement. Valve replacement also occurs when distribution mains are replaced or relocated.

The valve chamber replacement program will continue through the next several years. This program replaces existing chamber lids and access maintenance holes with larger diameter lids and new access ladders. This program will provide SPU maintenance staff with safer valve chamber access and meet industry safety standards.

Distribution System Hydrants. SPU maintains more than 18,920 fire hydrants. Annual condition assessment of fire hydrants is performed by various fire service agencies operating in Seattle's retail service area[1]. Damage to fire hydrants is also commonly reported between routine condition assessment cycles.

SPU resolves problems observed and reported by the fire service agency and the public. Problems are categorized into two levels. First, problems that make a hydrant unusable or unsafe to use are given the highest priority to repair or replace. Second, problems

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[1] Fire departments with jurisdiction in Seattle's retail service area include the Seattle Fire Department, Shoreline Fire Department, Northshore Fire Department, North Highline Fire District, Burien / Normandy Park Fire Department, and King County Fire District 20.

such as minor leaks that do not affect a hydrant's availability for fire fighting and main flushing are given a low priority for repair or replacement. SPU's hydrant replacement strategy for obsolete hydrants is to replace these hydrants in areas when other water system projects are being constructed and 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 inoperable and repairs are not possible or exceed the cost of replacement. New hydrants may also be installed as part of new development.

Since 2006, approximately 5% of all services have been shifted from plastic to copper.

Distribution System Service Connections. SPU has more than 188,000 retail service connections, an increase of more than 5,000 services since 2006, mainly for new residential customers. Most of the services (86 percent) are for residential customers, almost 12 percent are for commercial customers, and the remaining 2 percent are for fire service. Of all service connections, 80 percent are ¾-inch diameter pipes. Currently 74 percent of service lines are copper, 15 percent are plastic, and 6 percent are galvanized steel. The remaining 5 percent are made of other materials.

Service lines made of plastic or galvanized steel are more susceptible to failure and are now no longer used. Prior to 1947, all of the service lines were made of galvanized steel, and these have been primarily replaced with copper. Between 1968 and 1984, SPU installed or replaced approximately 40,000 small services (3/4-inch to 2-inch) with plastic tubing. The past 4 years of data shows that approximately 60 to 80 percent of small service failures were due to leaks on substandard pipes such as plastic and galvanized steel.

Prior to 2003, SPU's approach to renewal of small water service lines was "fix when fail." The cost of this primarily reactive strategy for some services has been high in both SPU's direct repair cost and social impact costs, such as damage to customer property, roads, and the environment. In 2003, a plastic service renewal pilot program began whereby blocks of plastic services were proactively renewed. In 2005, the programmatic approach was modified from block renewal to critical service renewal whereby plastic pipes with high risk costs were identified and renewed first. As part of the service renewal program, approximately 5 percent of all services have shifted from plastic to copper since 2006.

The current water service renewal program consists of both reactive and proactive components and is described more fully in Section 5.3.3.4.

Distribution System Meters. Each service line is fitted with a water meter used to determine customer consumption and charges. Nearly 92 percent of SPU meters are small (3/4-inch and 1-inch).

SPU has installed approximately 1,500 radio frequency modules on difficult-to-read meters. This form of automated meter reading (AMR) allows these meters to be read in walk-by mode more safely and at less cost than traditional meters. Examples of where AMR is cost-effective and used at SPU include:

- Meters that are a safety hazard and/or require costly setup to read visually, mostly due to being located in an area with traffic hazards.
- Clusters of meters located in larger vaults with heavier lids, which pose an injury risk to meter readers when repeated frequently.
- Meters located in parking areas that are unreadable when a vehicle is parked over them, leading to frequent estimated bills.
- Meters that tend to get buried and/or overgrown and require frequent clearing.
- “Deduct” meters owned by the customer and located on private property in hard to access locations, leading to lengthy time required to get a reading.

5.3.2 Distribution System Operation

SPU’s water distribution system is primarily served by gravity, but pumps are used to serve some pressure zones. To control flow and storage levels, SPU water system operators at the Operations Control Center operate pump stations, valves and other water system components using the remote control capability of the SCADA system or by directing crews to locally operate field equipment. The current SCADA system, which was installed in 2006, 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.

In addition to the control room at the Operations Control Center, SPU has a backup control room at the SPU North Operations Center. The backup control room has been improved to substantially reduce start up time to begin system monitoring and control from that location.

Additional information on system operations, particularly the Operations Planning and Scheduling function, is provided in the appendix for Water System Management and Operator Certification.

5.3.3 Distribution System Maintenance

SPU has prepared a number of SAMPs for each major class of distribution system infrastructure components and plans on updating as needed.

Proper maintenance of distribution system components ensures that SPU will be able to deliver reliable water service by reducing the risk of unexpected failures. SPU has prepared a number of strategic asset management plans (SAMPs) for major classes of distribution system infrastructure components. The SAMPs outline maintenance strategies for each asset. Summaries of those maintenance strategies are provided below.

5.3.3.1 Watermains

The most significant maintenance for watermains is leak assessment and control, watermain repairs and flushing. Watermain break/leak data from the past 22 years indicate that approximately 100 to 170 watermain failures (leaks and breaks) occur each year, with an average of 150. Approximately one-third of the failures, however, are joint leaks which do not always require a complete watermain shutdown. Also, repair of leaks from corrosion-related pinholes do not usually require complete shutdowns. Small watermain leaks can be repaired “live” by throttling adjacent valves and reducing the flow in the watermain. Only large breaks involve a complete watermain shutdown.

Watermain failures require immediate response. SPU distribution staff has been consistently meeting the service level target for problem response (90 percent problems responded to within one hour). To further optimize resource utilization, reduce lifecycle cost, enhance asset data and knowledge, the following improvements are being made:

- Implementing a Field Operations Mapping System with Automatic Vehicle Location capability: This improvement displays active maintenance crew/vehicles and work order locations on computerized maps, allowing the nearest equipped crew/vehicle to be dispatched quickly and address the problem.

- Implementing a MAXIMO Upgrade: This project improves the work order management process and asset data using SPU’s computerized maintenance management software called MAXIMO.

- Proactive leak survey and condition assessment to reduce high risk watermain failures.

Other watermain maintenance practices include watermain flushing. Additional information on watermain flushing is provided in Chapter 3.

5.3.3.2 Reservoirs and Tanks

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

5.3.3.3 Water Pump Stations

Pump stations in the distribution system are maintained in the same manner as described for the transmission system pump stations in Chapter 4. The asset management approach used by SPU to optimize pump station inspection and repair is Reliability Centered Maintenance (see RCM in Transmission Section Maintenance – Water Pump Stations). RCM programmed maintenance procedures have been completed for Augusta, First Hill, Broadway, and View Ridge Pump Stations, and the preventative maintenance schedules have been optimized and updated in MAXIMO. Additional pump stations are planned for RCM review in the future. In cases where changing the type or frequency of maintenance will not bring the asset to acceptable functional performance, RCM identifies capital improvements needed to address the performance requirement. Other capital improvements may also be revealed during the RCM process. For example, the RCM process for View Ridge Pump Station identified a change in the operational requirements for View Ridge Pump Station which, in turn, resulted in installation of an 8-inch pressure regulating valve (PRV) and bypass line at View Ridge Pump Station.

5.3.3.4 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. Between 2005 and 2011, SPU responded to an average of 110 valve-related problems per year, or approximately 0.5 percent of all valves. 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.

Due to a shift in priorities, the routine operation work of exercising large valves, 16 inches or larger, is performed less frequently than in the past (prior to 2003). There have been no demonstrated negative impacts from this reduction in routine exercising.

As part of the Shutdown Block Analysis described in section 5.4.1.2, a GIS layer is being developed to identify the need for new isolation valves, or relocation of existing isolation valves. Cost effective system improvements can then be implemented as opportunities arise (e.g. third-party projects or asset failure).

SPU plans on reviewing and updating its maintenance strategy for distribution system gate valves in 2012.

Hydrants. Each fire service agency inspects hydrants located within its service area, generally on an annual basis. Defects are reported to SPU for repair. In 2010, SPU responded to approximately 2,200 work orders to address fire hydrant defects. During maintenance visits, SPU paints hydrants to prevent exterior corrosion and improve their appearance.

SPU will review and update the Hydrant SAMP and associated maintenance strategy in the near future.

Service Connections. Maintenance related to service connections includes leak investigations, minor repairs on service lines, and replacement of broken valves, rods, or fittings. In 2011, an analysis was performed to define the asset management strategy for services, which is summarized here. SPU's water service renewal program consists of both reactive and proactive components:

- Reactive renewals include asset failure renewals due to emergency or non-emergency breaks, leaks, or mechanical failures (shutoff valve or meter failures), typically reported by customers. Reactive renewals called "demand renewals" are also identified by SPU staff when other projects trigger the need for a service connection replacement, such as during watermain relocation/replacement, service upsizing/downsizing, or "companion" renewals (substandard service pipes located in the same trench as another excavated water asset, which would likely fail during backfill and compaction).

- Proactive renewals include opportunity renewals and critical renewals. Opportunity renewals are performed when other projects, typically transportation-related projects, are restoring street pavement at no cost to SPU, which can be as much as 40 percent of the total cost to replace service connections. Critical renewals target small services where the remaining life is projected to be short and the consequences of a break would likely be significantly higher than typical. For example, a "critical" site may be in a steep slope or landslide area, or in high volume traffic roads offering few options for detouring traffic.

In addition, SPU has observed through practice that proactive service retirement is not cost effective, and, therefore, most service retirements are carried out reactively. Inactive service pipes are typically retired when leaks develop, new services replace the obsolete service, or the unused service is in conflict with or is abandoned with new right-of-way improvements or watermain work.

Meters. SPU's retail water meters ensure proper billing for water use as well as for wastewater services. Meter problems may be identified at the time of meter reading, such as when broken meter dials are found, or by the billing system, such as when consumption is much higher or lower than what is expected for a customer based on historical information. Metering issues may also be discovered when customers inquire about unusually high bills. Such issues may lead to testing, repair or replacement of a meter depending on its size and customer class.

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 less expensive to replace than repair them.

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. In 2009 and 2010, SPU replaced approximately 125 large retail meters per year.

SPU does not typically perform maintenance activities for small meters since repairing small meters is not cost-effective and it is generally less expensive to replace a small meter than repair it. In 2009 and 2010, SPU replaced about 1,700 small meters each year, or less than one percent of all meters each year.

Existing meters may be retrofitted, or new meters may be equipped, with radio units for AMR to allow walk-by meter reading when more cost-effective than visual reading. Currently, this type of installation is determined on a case-by-case basis.

Update of the Meter SAMP is planned for 2012.

5.3.3.5 Record Keeping and Reporting

SPU uses its MAXIMO work management system to capture asset failure and maintenance history. A MAXIMO reimplementation project commenced in March 2010 and is planned to be completed in 2012. This project will accomplish the following objectives:

- Improve data collection reliability and consistency.
- Improve data accuracy to assess asset maintenance needs and asset life-cycle costs.
- Improve service delivery problem response and remedy through improved work planning and improved GIS interfaces for field crews to access information and enter data.

SPU uses a geographic information system (GIS) to record and display locations of physical assets and problems. This tool is also used to review shutdown blocks, gridding and hydrant spacing, identify critical assets and develop asset management strategies.

5.4 NEEDS, GAPS, AND ISSUES

The primary needs, gaps, and issues facing SPU's distribution system in the coming years are related to distribution system assessment, asset management planning, distribution system improvements, and opportunities presented by third-party projects. The following subsections summarize these issues and SPU's approach to addressing them.

5.4.1 Distribution System Assessment

The Distribution System business area is the most asset-intensive of the business areas for the drinking water system. In recent years, SPU has been reviewing needs and gaps related to maintenance, rehabilitation and replacement of these assets. SPU identified as near-term priorities the need for conducting watermain condition assessments and a shutdown block analysis, as described below.

5.4.1.1 Watermain Condition Assessment

Parts of SPU'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 and break rates, SPU has limited information of the condition of watermains, especially those in critical locations. SPU uses an asset management framework to prioritize capital investments for watermains. Priority is given to replace or rehabilitate pipes that have reached the end of their economic life, and replace or rehabilitate critical pipes before they fail. Critical watermains are defined as pipes essential for service delivery or those with high consequences of failure. Critical watermains, which meet threshold criteria will undergo watermain condition assessment, if feasible. The threshold criteria used to determine criticality are under review.

As noted in Chapter 4, SPU conducted in 2007 a leakage test of Cedar River Pipeline 2 from Volunteer Reservoir to Maple Leaf Reservoir (also known as the 430 Pipeline) using “smart ball” technology to assess its condition. This initial phase of a proactive leak detection pilot was successful, and the program is being expanded. The expanded pilot will ascertain the condition of several of the most critical watermain segments by assessing for leaks and/or remaining pipe wall thickness. If critical watermains are found to be in need of repair, they will be repaired or given a high priority for capital investment to rehabilitate or replace prior to pipe failure. This evaluation will be based on asset management principles.

5.4.1.2 Shutdown Block Analysis

When one or more valves are closed to isolate a portion of the distribution system to make repairs or install new pipes or appurtenances, the area that no longer has water flowing is called a “shutdown block.” Any water services or hydrants within the shutdown block area would experience a service interruption. A simple example is when a pipe segment is taken out of service by closing valves at each end and service delivery is interrupted along the pipe segment. Depending on the pipe network configuration, a shutdown block may cover more than one city block.

SPU has completed a shutdown block analysis in which each pipe segment in the retail service area was evaluated to determine the service delivery impact if that pipe segment is taken out of service. In this context, service delivery impacts are based on the number of customers, the number of hydrants, and the flow rate in the pipe. Pipe segments associated with High Impact Shutdown Blocks (HISB) will be identified on a GIS layer. The HISB GIS layer will be used during the planning phase of redevelopment and third-party projects to reduce the size of the shutdown block and mitigate service delivery impacts with the installation of additional isolation valves or watermains. The HISB GIS layer will also be used during emergency shutdowns to improve operational response and customer service.

5.4.2 Asset Management Planning

> ***What do you mean by "asset management"?***
>
> *Asset Management is an approach to making decisions about operations and maintenance work and capital investments that 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.*

As noted in the *2007 Water System Plan*, important asset management planning documents that SPU uses include strategic asset management plans (SAMPs). 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) and describes relevant assets and service levels, operations and maintenance strategies, replacement/renewal capital plans, and decision tools and models for that asset class. In some instances, maintenance strategies may be developed separate from a SAMP. Additionally, ongoing programs may be evaluated to determine near-term investment strategies, which are documented in what SPU calls a Programmatic Business Case. The complexity of the asset class and the complexity of the management strategy for the asset class determine which documents are most appropriate. Watermains, for example, require a Programmatic Business case, a SAMP and a maintenance strategy.

Since the Distribution System Business Area is the most asset-intensive business area for SPU – requiring major investments and significant resources to maintain – SPU has completed initial versions of SAMPs for all of the relevant asset classes in the distribution system. As noted previously in Section 5.3.3.4, in 2012 SPU plans to update the Meter SAMP and gate valve maintenance strategy. Additionally, the Water Distribution Pipes SAMP and Programmatic Business Case will be updated in 2012. SPU also plans on completing in the next few years updates to the Valve SAMP, and Hydrant SAMP and maintenance strategy.

5.4.3 Distribution System Improvements

SPU has a capital program for distribution system improvements. This program is used to identify, prioritize and fund seismic upgrades of the backbone pipeline system and fire flow and pressure improvements. The program may also consider cleaning and lining as an option for making system improvements in areas with unlined cast iron pipes. These aspects of the distribution system improvement program are described in the following subsections.

5.4.3.1 Backbone Pipeline System Seismic Upgrades

The benefits of seismic upgrades will be considered when pipe replacement projects with multiple benefits are prioritized and implemented.

As noted in the *2007 Water System Plan*, SPU investigated cost-effective approaches to mitigating the effects of earthquake pipeline damage on the water system functionality, including line valves to isolate the Duwamish River Valley area and reservoir valves to retain water in storage for drinking water and firefighting. Additionally, replacement of certain existing watermains with seismically resistant pipe can be cost-effective when the watermain needs to be replaced for other reasons, such as when third-party projects require relocation of the watermain. For example, the seismic upgrades in the Duwamish River Valley area occurred when SPU took advantage of opportunities created by Seattle Department of Transportation projects.

SPU has completed some seismic upgrades in conjunction with other projects, but some work remains, specifically completion of the seismic backbone for an 800-foot section of watermain located in the Duwamish River Valley area on the west side of Beacon Hill in the vicinity of Interstate 5 and the Burlington Railroad line at Spokane Street. Also, installation of additional valves along the general boundary of the liquefiable soils in the Duwamish River valley is planned. Exact locations, operating strategy, hardware, and SCADA requirements are yet to be defined. The benefits of other seismic upgrades will continue to be considered when pipe replacement projects with multiple benefits are identified and implemented.

5.4.3.2 Fire Flow Improvements

Although the majority of the SPU's hydrants are able to deliver more than adequate flows to combat fires, there are areas inside and outside of the City of Seattle where SPU's water system has hydrants that cannot deliver fire flows to existing buildings under current codes required for new buildings. This can be caused by a combination of factors including pipes with small diameters or areas with low water pressure due to older design standards, or pipes whose interiors have been reduced by deposits. There are also areas that were originally built to now obsolete fire codes, most notably the Arbor Heights area annexed to the City of Seattle in 1954.

Although SPU is not legally obligated to upgrade the existing system to meet current standards, SPU's distribution system is upgraded to current fire flow standards as needed for development/redevelopment and as other system improvements are made (see section 5.4.4).

In 2011 SPU and the Seattle Fire Department (SFD) formed a Joint Executive Team (JET) to enhance coordination between the departments in delivering fire protection services to the public. The JET will set policies to improve fire hydrant maintenance and testing practices, as well as communication between SFD and SPU's water system control center and emergency crews just prior to and during fire fighting. The JET also reviews and prioritizes fire flow improvement projects, the latest one being the Arbor Heights fire flow improvements expected to be completed by the end of 2012.

SPU also intends to engage in similar discussions with other fire departments having jurisdiction in SPU's retail service area.

5.4.3.3 Watermain Cleaning and Lining

SPU's distribution system contains more than 700 miles of unlined, cast iron pipes – approximately 42 percent of all watermains. 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, lowers the pressure of water delivered to customers, increases pumping costs, and causes water quality problems such as discoloration, low chlorine residuals, and undesirable tastes and odors.

Replacing all of these pipes with new ductile iron pipes would be very costly. A less costly alternative to pipe replacement is to clean (scrape and remove the tuberculated areas) and then apply a lining to the interior of the pipe. This pipe rehabilitation method has been proven elsewhere to restore flow capacity, eliminate discolored water, reduce pipe leakage, and extend the life of pipes. Since cleaning and lining work generally does not require pipeline excavation, there is also less disruption to the community than with pipe replacement.

SPU completed a pilot cleaning and lining project in 2007 on approximately 19,130 feet of unlined, cast iron pipe in the Ballard area, and found this rehabilitation technique to be successful. The costs for completing the cleaning and relining, including associated costs such as laying temporary water service mains and installing flushing stations, was approximately $153 per foot, which is significantly less than the cost of pipe replacement. Issues with managing high pH levels shortly after construction, which are associated with the lime in the new cement mortar lining leaching out, can be managed through the use of unattended flushing stations. Water quality, as indicated by chlorine residuals, significantly improved after lining. While customers in the area did complain about brown water from valve operations and tastes and odors associated with the new service lines used by the contractor, the overall impact to the community was minimal in comparison to pipe replacement projects.

In its options analysis to address fire flow, water quality, or pressure issues in the distribution system, SPU considers the use of cleaning and lining as an alternative to replacement of deteriorated unlined, cast iron pipe. To date, no additional clean and line projects have been implemented.

5.4.4 Third-Party Projects

Projects initiated by third parties may require SPU to make system changes or provide an opportunity for SPU to make improvements.

Other agencies, utilities and private developers construct projects in the retail service area that can impact the distribution system. These third-party projects often necessitate SPU to make system changes that it would not otherwise do, but they can also present opportunities for improving flow capacity, pressure, reliability, and water quality in the distribution system at a reduced cost to SPU ratepayers. The following sections describe the impact on the distribution system from transportation projects and new development.

5.4.4.1 Transportation Projects

Transportation projects are third-party projects that can have a significant impact on the water system because of the need to relocate or protect existing water infrastructure. Also, transportation projects often create opportunities to renew or upgrade water infrastructure assets at a lower cost by taking advantage of the street opening and reducing pavement restoration costs.

SPU considers whether to relocate or retire water infrastructure for transportation projects when the existing water infrastructure would not be able to remain in its existing location due to grade conflicts, would no longer be accessible for maintenance and repair, would have increased consequences of failure after the transportation improvements have been built, or would have a high probability of failure due to damage during construction that cannot be remedied by protection measures. Water infrastructure may be retired when it is not needed for water delivery to specific water services or fire hydrants, for the delivery of fire flow to the surrounding area, and for delivery of water to surrounding areas such as usually provided by feeder mains. Watermain gridding is also considered in watermain decisions as a way to mitigate the impacts that dead-ends have on the system, such as to water quality and shutdown block size. Distribution mains that cannot be retired but are smaller or larger than the standard pipe sizes (8-inch for single–family residential areas and 12-inch for industrial and commercial areas) are evaluated for proper sizing prior to relocation. The evaluation usually involves hydraulic modeling of the present-day water system configuration and expected future uses and densities.

If water infrastructure does not need be relocated and is not slated for retirement, SPU may choose to protect it in place or take the opportunity to renew or upgrade it. SPU has developed a Watermain Replacement Opportunity Model, which was described in the *2007 Water System Plan*, and uses it to make data-driven decisions about whether to protect each existing watermain or to replace it. If the cost savings from the concurrent work with the transportation project are substantial enough, and/or the condition of the existing watermain is deteriorated, the model will indicate that the watermain is a candidate for replacement. The watermain may be replaced in kind, upsized or downsized depending on current and anticipated capacity requirements.

The extent of transportation improvements in Seattle's retail service area by Sound Transit, Washington State Department of Transportation (WSDOT), Seattle Department of Transportation (SDOT), and the City of Shoreline is expected to remain high at least through the first six years of the planning period, with the larger projects being as follows:

- SR99 Improvements through downtown Seattle by WSDOT, including new tunnel construction and demolition of the existing Alaskan Way Viaduct.
- Seattle Central Waterfront Redevelopment by SDOT.
- First Hill Streetcar implementation funded by Sound Transit and led by SDOT.
- Design and construction of the University, North, and East Links of the light rail system by Sound Transit.
- Aurora Ave/SR99 redevelopment between 192nd Street and the King-Snohomish county line by the City of Shoreline.
- The replacement of the SR520 highway, and improvements to the I-5/SR520 interchange by WSDOT.

- Arterial street resurfacing and reconstruction under the "Bridging the Gap" program by SDOT.

Because these transportation projects are led by third-parties, the schedule for completion is not within SPU's control and is subject to change.

5.4.4.2 Redevelopment

Redevelopment activities can have a substantial impact on the ability of the existing distribution system to provide sufficient water to customers and for fire flows. Redevelopment typically increases the population density of an area and can increase the quantity of water that must flow through SPU's distribution system pipes. Rezoning can also change distribution system requirements, particularly when single-family residential parcels are rezoned to mixed or commercial uses. Most often, extension of the distribution system or improvements to existing watermains in the redeveloped area becomes necessary to accommodate higher fire flows. Detailed hydraulic models or hydrant flow tests are used in conjunction with fire flow requirements provided by the fire department[1] to identify potential watermain improvements when properties are redeveloped, as well as when new development takes place.

New developments must meet the current fire code, and new service connections must be made to standard watermains. SPU reviews and provides a water availability certificate for each development as part of the local government's building 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. Developers are required to pay for connection to the system. New tap installations are directly billed to the customers.

5.4.5 Service to Shoreline

SPU is in discussion with the City of Shoreline about how SPU's infrastructure within the City of Shoreline could be transferred to the City if they are successful in getting voter approval to form a utility. With conceptual agreement on a sale of assets in 2020, SPU and Shoreline will attempt to reach agreement on how the

[1] See footnote on page 5-9 for fire departments with jurisdiction in SPU's retail service area. For the City of Seattle, fire flow requirements are defined by the Seattle Fire Code (SMC 22.600). Fire flow standards for unincorporated King County are defined by KCC 17.04 and 17.08.

systems would be separated and utility functions would be transferred, and at what cost.

5.5 IMPLEMENTATION/ACTION PLAN

As described in this chapter, the major needs for managing the distribution system to meet service level targets include distribution system assessment, asset management planning, distribution system improvements, and opportunities presented by third-party projects. SPU has identified the following actions to address these needs:

- Manage retail service delivery, problem response and leakage to meet service level targets.
- Complete analyses to determine whether to decommission Trenton Standpipes and Volunteer Park Standpipe.
- In a pilot effort, assess the condition of a portion of the most critical watermain segments and, if needed and supported by analysis, repair, rehabilitate or replace the pipe prior to anticipated failure. Expand the initial condition assessment pilot, if appropriate.
- Improve operational response and customer service by using information from the watermain shutdown block analysis in project and emergency shutdown plans.
- Complete additional asset management documents, including updates to the Meter SAMP, the Hydrant SAMP and maintenance strategy, and the Valve SAMP and maintenance strategy.
- Complete the remaining seismic backbone upgrades to the distribution system that serve the Duwamish River Valley.
- Consider the use of cleaning and lining as an alternative to replacement of deteriorated unlined, cast iron pipe to address pipeline life, fire flow, water quality, and pressure issues in the distribution system.
- Continue to work with the Seattle Fire Department to improve fire hydrant maintenance and testing practices, better coordinate communication between SFD and SPU's water system control center and emergency crews just prior to and during fire fighting, and prioritize fire flow improvement projects. Engage in similar discussions with other fire districts.

- Continue working with developers where watermain replacements or upgrades in redevelopment areas are required to meet current fire flow requirements and watermain standards.

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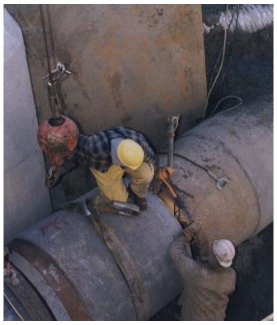
PART II: PLAN IMPLEMENTATION



Part I of the *2013 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 2040, 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 described SPU's drinking water CIP projects and O&M programs and 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 capital facilities plan (CFP) and O&M budget outlook through 2040 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 *2007 Water System Plan* was prepared, SPU has been implementing 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's 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.

Elements of SPU's asset management approach were described in the *2007 Water System Plan.* One key element is development of a business case for each project (formerly known as a Project Development Plan) that includes a clearly define problem, an analysis of alternative solutions, and a benefit-cost analysis to inform a preferred alternative decision. Business cases for projects or programs that are projected to cost $1,000,000 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 $1,000,000 must be reviewed by the AMC for the water line of business. Such approvals support asset management by making deliberate decisions about projects and programs in a transparent manner, fully informed by financial, environmental, and social impact life-cycle costs and benefits of the business case.

Many of the projects that are included here have not yet gone through a final business case evaluation and review by the AMC. The project descriptions, scope, budget and timing are based on best current planning.

1.2 Business Area Actions and Costs

Part I of this *2013 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 2013-2018 CIP budget, summarized according to business areas, is presented in Table 1-1. The detailed draft CIP is provided with the Capital Facilities Plan 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 2013-2018
(2012-2017 Adopted CIP, plus 2018 Estimate, in thousands of 2011 dollars)

Business Area	2013	2014	2015	2016	2017	2018	Total
Water Resources	5,359	8,239	8,076	11,070	9,147	3,245	**45,135**
Water Quality and Treatment	5,088	1,458	187	190	700	1,600	**9,223**
Transmission	2,910	2,898	2,898	2,894	3,013	3,013	**17,626**
Distribution	26,098	24,257	25,270	25,237	25,455	25,019	**151,335**
Other	22,016	23,945	21,238	19,807	22,636	16,890	**126,533**
Total	**61,471**	**60,797**	**57,668**	**59,199**	**60,951**	**49,767**	**349,853**

1.2.1 Water Resources

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

- Implement the 2013-2018 Water Use Efficiency program for the Saving Water Partnership, which is budgeted at $1.7 million per year.
- Implement the Seattle-only low income conservation assistance program at a cost of $650K per year.
- 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 $1.7 million in 2013-2016 to complete this work.

- Complete the Overflow Dike Improvements. The CIP includes $3.6 million in 2013-2014 for this work.

- Implement any capital improvements resulting from regular inspections by Ecology and FERC of SPU's dams and related infrastructure, such as spillway gates and dam failure warning systems. The Dam Safety program CIP totals to almost $700K in 2013-2018, and also includes costs in future years for work anticipated after planned inspections.

- Design and construct the Morse Lake Pump Plant, which involves installation of axial flow floating pumps and improvements to the discharge channel. The CIP includes a cost estimate of $23.2 million in 2013-2017 to complete this work, but this estimate may increase as further engineering and design are completed.

1.2.2 Water Quality and Treatment

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

- The Maple Leaf Reservoir Replacement Project is estimated to cost $47 million and is scheduled to be on-line in 2012.

- The existing open Volunteer Reservoir may be decommissioned rather than constructing a new buried reservoir replacement at the site, but additional analysis is required to confirm this action. The CFP assumes that the reservoir will be buried by 2021 at a cost of $22.8 million.

- Roosevelt reservoir is planned to be taken out of service following the return to service and completion of Maple Leaf Reservoir and is targeted for decommissioning in 2015.

- The CIP includes $1.8 million in 2013-2015 to replace the gas chlorination facilities at Landsburg with liquid chlorination (hypochlorite) facilities to improve safety and security.

- The CIP includes approximately $100K per year for various smaller scale water quality and treatment facility rehabilitation and improvement projects that relate to public health protection and drinking water regulatory compliance.

1.2.3 Transmission

- The major CIP projects identified for the transmission system include the following:Implement cathodic protection for transmission pipelines, where cost-effective. This is estimated to cost $1.6 million per year in 2013-2022.

- The CIP includes $1 million per year for Transmission Pipeline Rehabilitation, including any additional work to mitigate the risk of pipe failure in the Tolt Slide area.

- The CIP includes approximately $100K per year each for air valve chamber replacements and system dewatering.

- Purveyor Meter Replacements are estimated to cost approximately $90K per year through 2016 and $200K thereafter.

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:

- Where cost-effective, reline or replace aging watermains, provide seismic upgrades to the backbone system, and improve pressures and fire flows. The draft six-year CIP includes more than $4.5 to 10 million per year for these Distribution System Improvements and Watermain Rehabilitation projects.

- Extend watermains and install new taps to new developments. The draft six-year CIP includes approximately $650,000 to $750,000 per year for watermain extensions and $4 million per year for customer-reimbursed new taps.

- Relocate, rehabilitate or replace water mains and appurtances impacted by other projects, primarily transportation-related projects. 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 $25.3 million for these types of projects.

- Replace leaking or substandard service connections, primarily plastic. The draft six-year CIP includes approximately $5.5 to 5.9 million per year for this ongoing work.
- Replace meters. The draft six-year CIP includes approximately $600,000 per year for this ongoing work.
- Upgrade or replace hydrants, valves, chambers and pump stations. The draft six-year CIP includes approximately $1 to $1.3 million 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 those related to the Cedar River Watershed Habitat Conservation Plan and watershed stewardship in both 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 (2012-2017 Adopted CIP, plus 2018 Estimate, in thousands of 2011 dollars)

Capital Improvement Program Projects	2013	2014	2015	2016	2017	2018	Total
Cedar River Watershed Habitat Conservation Plan	3,241	3,439	2,721	2,254	1,606	1,756	**15,016**
Watershed Stewardship	995	687	554	543	533	100	**3,412**
Technology	7,410	8,184	5,964	5,358	5,327	6,000	**38,242**
SCADA	466	457	443	408	355	400	**2,529**
Security	1,922	1,884	1,847	1,811	1,793	1,000	**10,258**
Heavy Equipment Purchases	2,951	1,934	2,979	2,156	1,931	2,500	**14,451**
In-Town Facilities	1,514	3,775	2,225	2,547	2,387	2,550	**14,998**
Regional Facilities	3,296	3,315	4,227	4,494	8,480	2,450	**26,262**
Emergency Storm Response	48	47	46	45	0	0	**187**
1% for Art	174	224	231	191	224	134	**1,177**
Total	**22,016**	**23,945**	**21,238**	**19,807**	**22,636**	**16,890**	**126,532**

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 2040, given what is known and anticipated at this time, including our understanding of future regulations. Beyond 2018, the range of uncertainty in project costs and timing is greater. While projections are shown through 2040, experience has shown that new requirements emerge and projections change over time. In particular, many programs are shown with uniform expenditures in each future year even though it is likely that the costs will be concentrated into some years as specific projects are identified and scheduled. In particular, this CFP does not address any potential major emergency or disaster which could lead to the need for a new major project. SPU would most likely attempt to smooth out expenditures, but this is not always possible.

The CFP budget estimate is provided as an appendix and summarized in Table 1-3. SPU's CFP totals to $1.4 billion for 2013 through 2040, which is 64 percent of what was spent in the previous 28-year period, in 2011 dollars. Approximately one-half of the current CFP is for improvement to and rehabilitation of the distribution system.

Table 1-3. Capital Facilities Plan Budget through 2040
(2012-2017 Adopted CIP, plus 2018-2040 Estimate, in thousands of 2011 dollars)

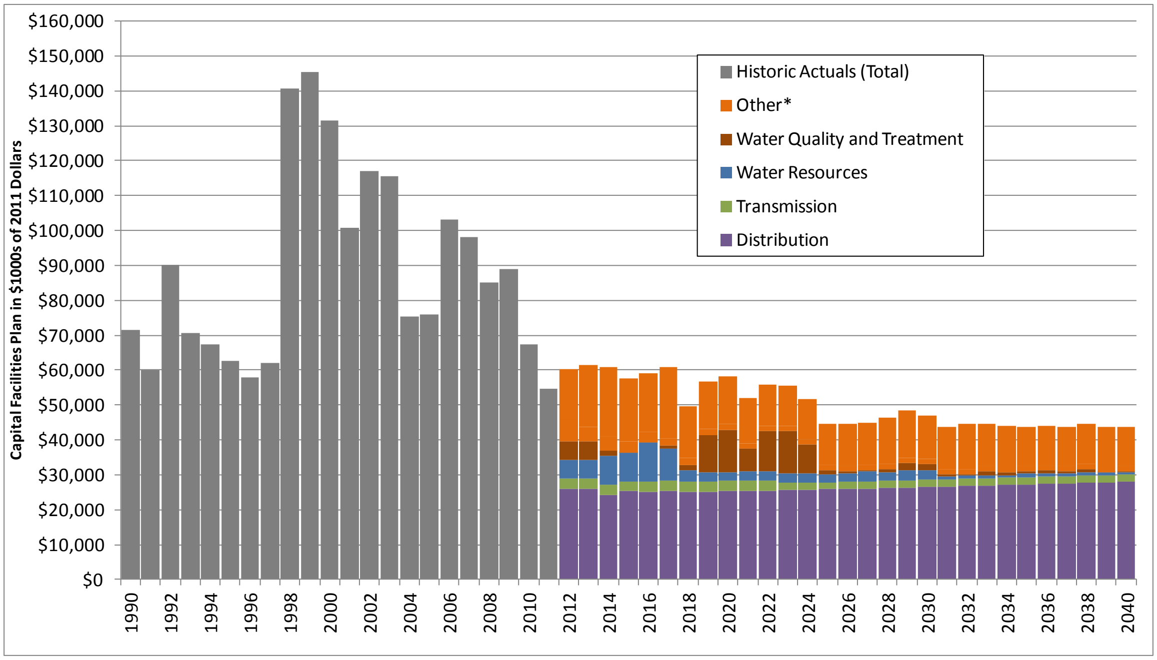
Business Area	2013-2020	2021-2025	2026-2030	2031-2035	2036-2040	Total
Water Resources	50,410	13,079	13,229	4,634	4,454	**85,806**
Water Quality and Treatment	31,723	39,400	5,800	3,450	2,250	**82,623**
Transmission	23,652	12,065	10,065	10,065	10,065	**65,912**
Distribution	201,712	128,029	131,247	134,778	138,630	**734,395**
Other*	157,318	67,018	71,071	67,699	64,407	**427,513**
Total	**464,815**	**259,591**	**231,412**	**220,626**	**219,805**	**1,396,249**

*See Appendix for additional detail.

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, but much lower than historical peak expenditures that occurred from 1998 to 2009. The first major new project is the Morse Lake Pump Plant Project (Water Resources). This is followed by increased expenditures in 2018-2025 to recover Lake Forest Park Reservoir and bury Volunteer and Bitter Lake Reservoirs (Water Quality and Treatment). Additional increases around 2030 are for improvements at the Tolt and Cedar water treatment facilities (Water Quality and Treatment). The long-range CFP also includes increasing costs in Distribution for an increasing need for watermain rehabilitation as the system ages.

SPU's *2007 Water System Plan* included a long-range capital facilities plan for the water utility. That plan covered the period 2007 through 2030. Table 1-4 compares the CFP budget for the

2007 plan with the CFP budget presented in Table 1-3 and Figure 1-1.



* Other includes Major Watersheds, Fleets, Facilities, Security, Information Technology, SCADA and other miscellaneous projects.

Figure 1-1. Historic and Proposed Capital Facilities Plan Spending through 2040

As Table 1-4 shows, SPU has increased its capital spending projections for the 2013-2020 period relative to that provided in its *2007 Water Systems Plan* primarily due to delays in large projects, such as the Morse Lake Pump Plant project, and increased expenditures for the distribution system.

Table 1-4. Comparison of Capital Facilities Plan Budget Estimates from *2007* and *2013 Water System Plans* (in total millions of dollars for the year range shown)

Water System Plan	2013-2020	2021-2025	2026-2030	2031-2035	2036-2040
2007 (in 2006 $s)	290	165	178	N/A	N/A
2013 (in 2011 $s)	465	260	231	221	220
Increase	**175**	**95**	**53**	**N/A**	**N/A**

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Chapter 2
Financial Program

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 intends 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, that 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 resulting in balances below this amount 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 the Subfund fall below the target balance, SPU must submit within one year 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 2010, 37 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 unanticipated 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 as much as 5 percent. Since this variation happens in the summer, when rates are higher than the winter, summer weather variation can result in annual water sale revenue shortfalls of up to 8 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 winter rates or increasing the base service charge 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 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 operational expenses and some taxes have been paid. While the legal requirement in bond covenants is 1.25, SPU's debt-service coverage policy target is 1.70. The higher target provides SPU flexibility when actual revenues are lower than projected. This flexibility enabled SPU to collect the necessary revenue to stay above the legal requirements, but below the policy target, when demand in the late 2000's and early 2010's was lower than originally projected and variable rate debt was refunded into fixed rate debt when market conditions changed. A commitment was made for the 2012-2014 rate study to meet the 1.70 target by 2014.

SPU's water utility is rated Aa1 by Moody's and AA+ by Standard and Poors.

The second key indicator is the debt-to-assets ratio. The debt-to-assets ratio is the outstanding debt of the utility divided by the sum total of its assets. The debt-to-assets ratio shows how reliant the utility is on debt to finance its infrastructure and how much flexibility is has to respond to unexpected circumstances. SPU's debt-to-assets ratio for the water system 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. To counteract this concern, SPU has generally decreased the levels of debt financing and has forecasted continuation of this trend in the future. As a result, in recent years, SPU has had excellent bond ratings.

While SPU has been generally decreasing the levels of debt financing of the capital improvement program, exceptions occurred in 2008 and 2009 when revenues fell to the point where cash available to fund the capital program was less than 20 percent of total spending, forcing more reliance on debt. Revenue financing of capital projects is expected to increase going forward because the binding financial policy has switched from cash-to-CIP to debt service. In order to meet debt service coverage targets, revenue requirements will generate more cash than needed to cover operating expenses and other financial policy targets. The excess cash will be put towards the capital program. By investing more current revenue in infrastructure, SPU will reduce its reliance on debt and thereby reduce its debt-to-assets ratio. The necessity of meeting the debt service coverage targets will drive rate increases in the coming years.

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

Table 2-1. Financial Revenues and Expenditures, 2005–2010 (in millions of dollars)

	2005	2006	2007	2008	2009	2010
Revenues						
Water Sales	136	142	144	149	179	184
Other (tap fees, interest income, operational grants, reimbursements, etc.)	11	17	26	16	24	16
Total	147	159	170	165	203	200
Expenditures						
Operations and Maintenance	60	62	77	81	84	79
Taxes	20	24	24	25	34	36
Debt Service	59	59	59	63	71	74
Revenue-Financed Construction	4	13	18	14	8	12
Total	144	158	178	183	197	201
Net of Revenues and Expenditures	3	1	(8)	(18)	6	(1)

2.3 FUNDING SOURCES

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

The primary source of funding for SPU's water utility is revenue derived from 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 declining capital expenditure as it emerges from a period of unprecedented investment in important capital projects, such as the water treatment facilities and buried reservoir program.

As stated earlier, debt service coverage is the binding financial policy moving forward. With debt service as the binding constraint, revenues will be in excess of operating expenses, leaving excess cash to fund the CIP. As a result, from 2012 through 2040, SPU plans to meet or 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 2010, water sales made up 95 percent of operating revenues. Rates must provide sufficient revenue to operate the water system. Rate-design 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.

If we use less water, shouldn't it cost less?

Most of the utility's costs are the same whether we sell a lot of water or a little. These fixed costs include debt service (principle and interest paid for past capital projects) and the labor needed to operate the system, treat the water, and respond to problems 24 / 7.

When we sell less water, we need to charge more per gallon to be sure that SPU makes enough revenue to operate and maintain the water system while meeting financial policies set by the City Council.

The affordability of rates to retail customers is also an issue considered by City Council during rate setting.

In recent years, City Council has set rates for 3-year periods. Water rates were last set in 2011 and cover 2012 through 2014. These rate schedules are provided in the appendices.

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 streamflows are high and demand is low, and summer, when streamflows 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 five hundred 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[1], above 18 CCF, is set at an even higher rate to discourage the use of very large volumes of water, often for irrigation.

System-wide average rates[2] are likely to increase faster than the rate of inflation, particularly in the near-term. A significant portion of current and near-term rates are due to debt service on prior capital investments, such as the Tolt and Cedar Water Treatment Facilities. Going forward, those effects are still felt as future CIP and O&M spending will put pressure on debt service coverage requirements, thereby requiring increasing rates. Additionally, future rate levels depend on revenue requirements as well as the amount of water sold. With demand for water forecasted to generally decline through 2040, there will be no growth in water sales to absorb any increases in revenue requirements.

While the above discussion applies to 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. 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. Going forward, the CIP contains fewer regional projects in the areas of supply, treatment, and transmission. The rates charged by SPU's wholesale customers to *their* customers include the cost of the wholesale customer distribution systems, and would be different than what SPU charges its retail customers.

2.3.2 Debt Financing

From 2012 through 2040, an average of 69 percent of the Capital Facilities Plan (CFP) is expected to be financed with debt, as shown in Figure 2-1, below. Debt is expected to be used to finance 64 percent of CIP through 2029 and 78 percent thereafter. Until 2030, debt service coverage is expected to alter the way capital projects are financed. Because of the large debt incurred since 1999, a larger portion of revenue must go to finance capital facilities in order to meet bond covenant requirements and financial policy targets. In order to maintain debt service coverage requirements, revenue is higher than otherwise would be required.

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[1] The third tier was instituted in 2001 in response to Ordinance 120532, the Initiative 63 Settlement Ordinance.
[2] System-wide average rates are defined as the average rate paid by all customers of the utility. It is computed by taking the total water sales revenue divided by total system water use by all customers.

The additional revenue will then be utilized to fund the current capital program, reducing debt issuance and future debt service requirements.

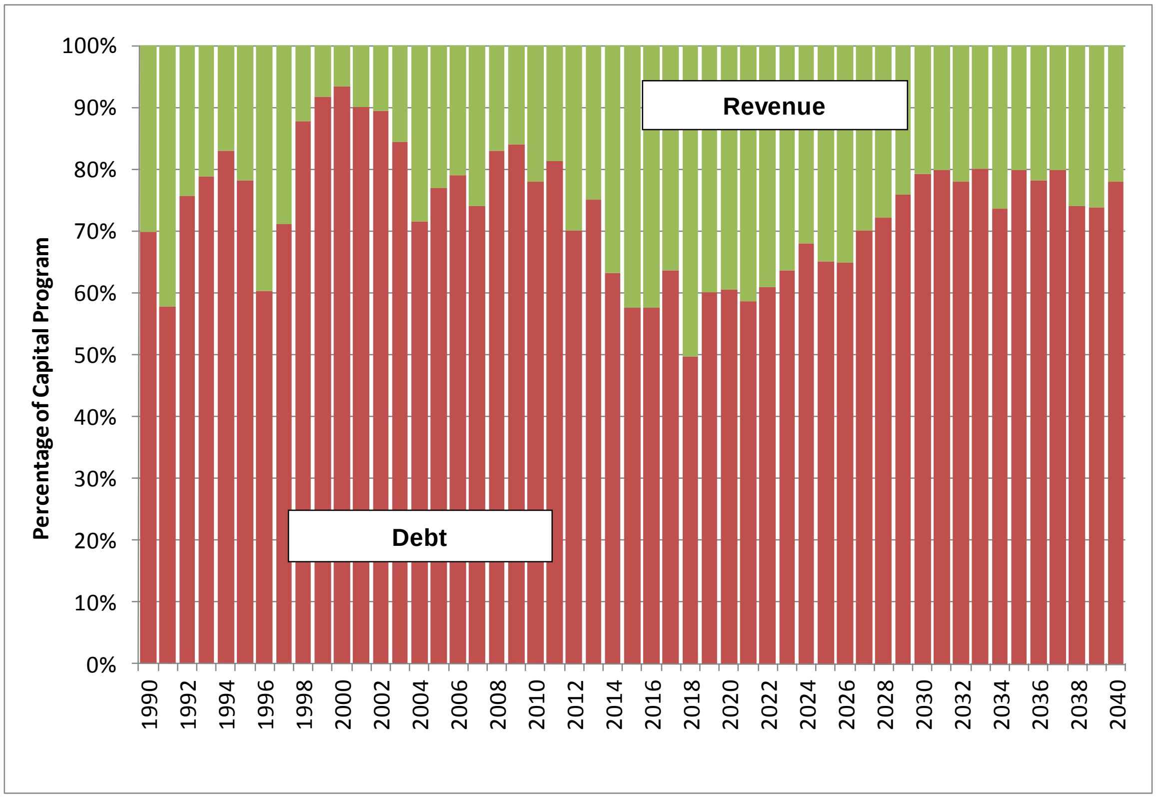

Figure 2-1. Past and Planned Debt Financing

2.3.3 Debt-to-Assets Ratio

Over the past 20 years, SPU has been borrowing extensively in order to finance the capital program and the building of new assets. This level of borrowing has increased the debt-to-asset ratio 40 percent over the past 15 years, peaking at 75 percent in 2012, as shown in Figure 2-2. However, as the utility enters a new phase of the asset life cycle, and generational asset construction slows, borrowing levels will decrease. Along with increased revenue financing of capital projects, this decreased borrowing will lower the debt-to-asset ratio in the future.

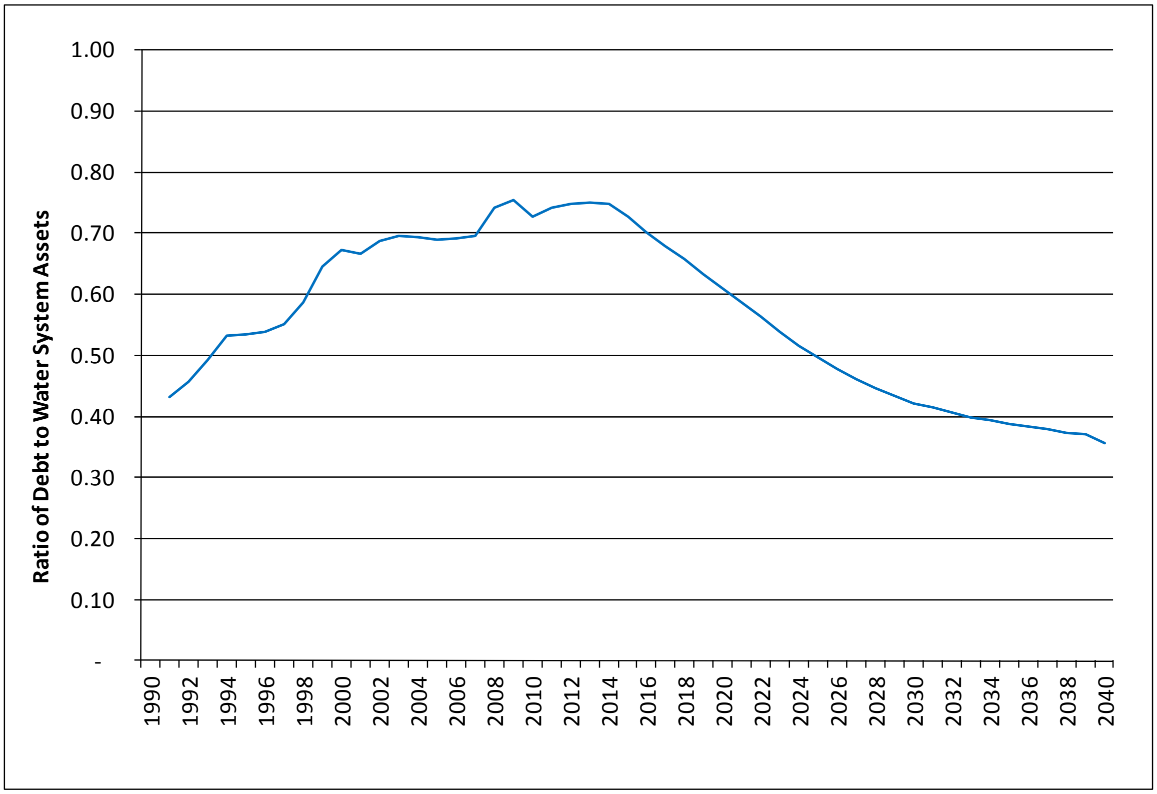

Figure 2-2. Past and Projected Debt-to-Assets Ratio

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 current approach strikes a balance between short-term debt service needs and long-term financing that will provide the utility stability and address important capital needs and operating requirements.

2.4 Financial Model Cash Flow Analysis

The capital improvements summarized in the Part II, Chapter 1, together with projected operating expenses through 2040, 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. The debt service coverage of 1.7

controls rates through 2030. After 2030, SPU's financial policy targets for net income and cash-to-CIP become binding for rates.

Table 2-2. Summary of Water System Cash (in millions of dollars)[1]

Revenue/Expenditures	2015	2020	2025	2030	2035	2040
Revenues						
Water Sales	241	283	318	342	398	458
Other (tap fees, interest income, operational grants, reimbursements, etc.)	21	24	26	28	32	35
Total Revenues	**261**	**307**	**345**	**370**	**430**	**493**
Expenditures						
Operations and Maintenance	102	127	158	197	243	289
Taxes	42	50	58	64	76	89
Debt Service	91	101	107	94	95	97
Revenue-Financed Construction	25	26	19	13	13	16
Total Expenditures	**260**	**304**	**343**	**367**	**428**	**491**
Net Revenue	1	2	2	3	2	1
Debt Service Coverage	1.7	1.7	1.7	1.7	1.9	2.0
Debt-to-Assets Ratio	0.71	0.61	0.48	0.43	0.38	0.36
Cash Balance	8	11	13	16	20	24
Capital Improvement Program	**2013-2015**	**2016-2020**	**2021-2025**	**2026-2030**	**2031-2035**	**2036-2040**
Revenue Financing	66	129	116	82	67	82
Contributions in Aid of Construction	6	11	12	14	15	17
Debt Financing	135	198	220	256	296	327
Total CFP Financing	**206**	**338**	**348**	**352**	**378**	**426**

[1]Notes and Assumptions:

- 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.
- 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.
- Operations and Maintenance assumed to increase by 72 percent from 2011 through 2040 in real terms, or 1.8% compounded annual growth per year. For comparison, from 1990 to 2011, O&M costs have grown at an annual rate of 2.5% in real terms.
- The forecast assumes bond issues every other year at 5% interest and 30-year terms.
- The forecast assumes inflation of 2.5% per year.

Cash expenditure growth fluctuates throughout the plan. From 2013-2025, cash expenditure grows quickly as capital expense is larger than revenue. A historically large portion of the CIP during this period is to be funded by revenue-generated cash. The largest of these include capital programs such as Distribution System Improvements, Service Renewals and Watermain Rehabilitation and large projects such as Morse Lake Pump Plant and Bitter Lake Reservoir Burying/Floating Cover Replacement. From 2025-2030, expenditures slow as a result of decreased debt service and revenue-financed construction. After 2030, expenditure growth returns to earlier levels as operations and maintenance are the primary drivers of spending.

2.5 CONCLUSION

SPU has been making, and continues to make, significant investments to protect public health, comply with federal and state regulations, and replace aging infrastructure. While SPU has invested in major regional facilities in the past decades, the need is now shifting to significant capital investments to rehabilitate and improve the distribution system. Implementation of this water system plan will help to ensure that SPU meets its mission to provide reliable, efficient and environmentally conscious water utility services to enhance the quality of life and livability in all communities we serve.