PREPARING FOR CLIMATE CHANGE

Seattle
Office of Sustainability
& Environment

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Table of Contents

01 Introduction/Executive Summary

02 Climate Impacts in Our Region: Overview

03 Equity and Climate Change

04 Strategy Overview

05 Sector-Specific Actions

- Transportation
- Land Use & the Built Environment
- City Buildings
- Parks
- Drainage & Water Supply Systems
- Electricity System
- Community Preparedness

06 What You Can Do

Introduction/Executive Summary

Why do we need to prepare for a changing climate?

While we must make concerted efforts to reduce GHG emissions, historic emissions have and will continue to impact the global climate. Additionally, slow progress in reducing future emissions means that additional climate change will exacerbate the impacts communities are already experiencing. In 2015, we saw a glimpse of the type of extreme weather events expected to increase due to climate change:

- India experienced one of deadliest heat waves in world history in May. More than 2,500 people died as temperatures soared past 115 degrees Fahrenheit.
- The average annual temperature in the United States was the second hottest on record.
- The United States exceeded $10 billion in losses from extreme weather for the eighth consecutive year.
- The largest wildfire season in Washington history burned more than one million acres across the state, destroying hundreds of homes and other buildings, forcing the evacuation of entire towns, causing over $250 million in damages, degrading air quality to unhealthy levels, and claiming the lives of three firefighters.
- Thirty percent of the Pacific Northwest (Washington, Oregon, and Idaho) experienced a much greater than normal proportion of precipitation derived from extreme precipitation events, the highest such percentage in 20 years.

The most significant changes projected for the Pacific Northwest will be to temperature, precipitation, and sea level. Flooding, heat waves, and extreme high tides are not new challenges in Seattle and we have strategies for dealing with them. However, climate change will shift the frequency, intensity, magnitude, and timing of these events.

Temperature	• Increasing average annual temperature. • More frequent extreme heat events (days over 92˚F) and less frequent extreme cold events (x). • Natural variability (e.g. El Niño, Pacific Decadal Oscillation) will continue to be an important influence on in any given year or decade.
Precipitation, Snowpack, and Streamflow	• Wetter winters and dryer summers. • Declining snowpack. • Shifting streamflow levels as more precipitation falls as rain and snowpack melts earlier. • Increasing flood risk. • Increasing stream temperatures. • More extreme heavy rainfall events.
Sea Level	• Rising sea levels. • Exacerbated impacts of storm surges and high tides due to higher sea levels.

Seattle is preparing for a changing climate and the resulting economic, infrastructure, health, and other community impacts by integrating consideration of climate change into decision making and identifying mitigation and adaptation actions to enhance the resilience of services and infrastructure. The 2013 Climate Action Plan identified a range of actions to improve preparedness, including the need for a more comprehensive strategy. This document presents this strategy.

What are our Planning Priorities?

Seattle's overarching climate protection vision is to reduce emissions and prepare for impacts while building vibrant neighborhoods, fostering economic prosperity, and enhancing equity. To advance this vision, the following planning priorities were established for the preparedness strategy.

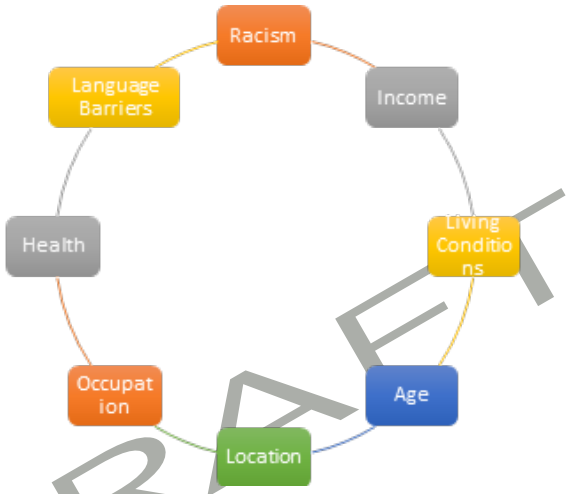
EQUITY: Prioritize actions that reduce risk and enhance resilience in frontline communities (e.g., communities of color, lower income communities, immigrant and refugee communities, disabled residents and seniors), as they are at greater risk from the impacts of climate change and often have the fewest resources to respond to changing conditions.

CO-BENEFITS: Design and implement resilience strategies that advance community goals by enhancing physical spaces and services in ways that support quality/livable urban environments, health, and social cohesion.

NATURAL SYSTEMS: Use nature-based solutions that leverage ecosystem services and foster natural systems resilience.

Why does climate change have disproportionate impacts?

Individual residents and communities will experience the impacts of climate change differently. For example, outdoor workers and people with pre-existing health conditions are at greater risk from heat events, those with lower incomes have fewer resources to repair flood damage, and people with limited English language proficiency have more limited access to government decision making processes.



Racism is a key factor influencing climate vulnerability. The legacy of institutional and systemic racism in our economic, government, and social systems has resulted-and continues to result-in the disproportionate distribution of the benefits and burdens of our society for people of color. Across the US, race is the most significant predictor of a person living near contaminated air, water, or soil.[1]

> The vulnerabilities in our communities are the result of decades of systemic exclusion from power and resources. To build resilient communities, we must address the root cause of vulnerability and build meaningful political power.
>
> While resilience is a response to a looming threat, we also see it as an incredible opportunity to (re) imagine a more just future for all. Deepening local democracy and sustainably centering the communities most impacted by climate change in mitigation and adaptation planning are key to realizing this future.
>
> - "Our People, Our Plant, Our Power: Community-Led Research in South Seattle, Got Green and Puget Sound Sage; March 2016.

WHY DO WE LEAD WITH RACE?

All historically disadvantaged groups – people of color, lesbians, gay men, people who are transgendered, women, people with disabilities, low-income households, to name a few – experience systemic inequity. Many people and communities live at the intersection of these identities, for example lesbians of color, experiencing multiple inequities at once. By centering on race and using tools that can be applied across oppressions, we increase the ability of all of us to work for equity.

-Seattle Race and Social Justice Initiative

1 Bryce Covert, "Racism and Discrimination Race Best Predicts Whether You Live Near Pollution," The Nation, February 18, 2016

In order to foster more just climate preparedness and avoid implementing strategies that exacerbate existing inequities, racial equity is incorporated as a priority in our climate preparedness planning.

How is the Strategy organized?

This strategy includes actions to be taken over the next five years and builds on the leading work at Seattle Public Utilities and Seattle City Light. The document is organized into the following sections:

- Climate Impacts
- Equity & Climate Change
- Sector-Specific Actions
    - Transportation
    - Land Use & Buildings
    - City Buildings
    - Parks
    - Drainage & Water Supply
    - Electricity System
    - Community Preparedness
- What You Can Do

CLIMATE IMPACTS IN OUR REGION: OVERVIEW

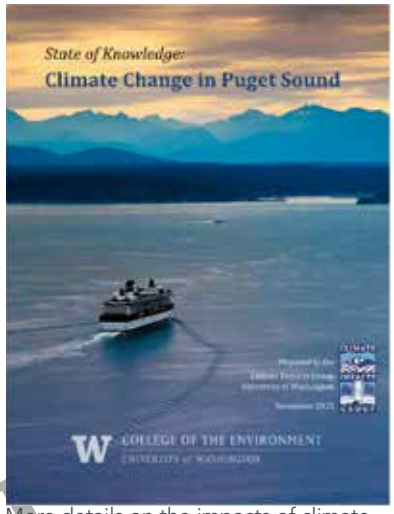
Projected Changes in Regional Climate

Puget Sound climate is expected to change rapidly in the coming decades as a result of rising greenhouse gas emissions. These changes, which include increasing temperature, more extreme precipitation, and rising sea level, will require shifts in how City departments prepare for and respond to impacts on City residents, infrastructure, services, and programs.

All scenarios show warming

Projecting changes in 21st century climate requires the use of global climate models and scenarios of future greenhouse gas emissions, which incorporate a range of assumptions about future changes in global population, technological advances, and other factors that influence the amount of carbon dioxide and other greenhouse gases emitted into the atmosphere as a result of human activities. Differences in the greenhouse gas scenarios, combined with differences in how individual models respond to those scenarios, result in a range of possible futures (referred to as climate scenarios) that can be used to evaluate climate impacts.

All climate scenarios show increasing annual and seasonal temperatures for the Puget Sound region, with the amount of warming dependent on how quickly greenhouse gas emissions rise (Table 1; Figure 1). For a high (or "business as usual") greenhouse gas scenario, average annual temperature in the Puget Sound region increases +5.5°F, on average, by mid-century.[1] Warming is lower—but still significant—for a low greenhouse gas scenario, which assumes that emissions peak at mid-century and then gradually decline. Under a low greenhouse gas scenario, average annual temperature in the Puget Sound region increases +4.2°F, on average, by mid-century. In both scenarios, warming is even more pronounced by the 2080s.[2] While natural variability will remain an important feature of regional climate, the Puget Sound region is likely to regularly experience average annual air temperatures by mid-century that exceed the range observed during the 20th century.



More details on the impacts of climate change on the Puget Sound region and ongoing climate risk reduction efforts can be found in *State of Knowledge Report: Climate Change in Puget Sound*, available at cig.uw.edu
(Source: UW Climate Impacts Group)

Representative Concentration Pathways (RCPs)

A significant factor in the rate and total amount of change that occurs with climate change is future greenhouse gas emissions and how global climate responds to those emissions.

To make projections of future climate, scientists use greenhouse gas scenarios – "what if" scenarios of plausible future emissions – to drive global climate model simulations. Both the greenhouse gas scenarios and global climate models are periodically updated to reflect advancements in climate science. The newest scenarios, used in the 2013 IPCC report, are referred to as Representative Concentration Pathways, or "RCPs". This document references the 'low' (by midcentury, emissions stabilize and then fall sharply – RCP 4.5) and 'high' (emissions continue to increase through 2100 – RCP 8.5) greenhouse gas scenarios.

1 "2050s" refers to the 30-year average spanning from 2041 to 2070. Changes relative to 1970-1999.
2"2080s" refers to the 30-year average spanning from 2070-2099. Changes relative to 1970-1999.

Change in…	Greenhouse Gas Scenario*	2050s (2040-2069, relative to 1970-1999)		2080s (2040-2069, relative to 1970-1999)	
		Mean	Range	Mean	Range
Average annual air temperature	Low (RCP 4.5)	+4.2°F	2.9°F - 5.4°F	+5.5°F	2.3°F - 11°F
	High (RCP 8.5)	+5.9°F	4.3°F - 7.1°F	+9.1°F	4.3°F - 17°F
Temperature of hottest days[3]	Average of RCP 4.5 and 8.5	+6.5°F	4.0°F - 10.2°F	+9.8°F	5.3°F -15.3°F
Temperature of coolest nights[4]	Average of RCP 4.5 and 8.5	+5.4°F	1.3°F - 10.4°F	+8.3°F	3.7°F - 14.6°F

*Under the low greenhouse gas scenario (RCP 4.5), global greenhouse gas emissions stabilize by mid-century and fall sharply thereafter. Under the high greenhouse gas scenario (RCP 8.5), emissions continue to increase through 2100 and beyond. RCP 8.5 is considered a "business as usual" scenario; global emissions are currently following this trajectory (footnote adapted from Raymond 2016)

Table 1. Puget Sound Region Projected Temperature Changes
Projected changes for the 2050s and 2080s (Source: Mauger et al. 2015)

More extreme heat is also expected, although the frequency and intensity of extreme heat events may be moderated slightly in areas adjacent to Puget Sound. Analysis by Seattle City Light[5] found that the Seattle metropolitan area is likely to see 18 additional days (±6 days) of temperatures above 86°F by the 2050s.[6] Similar findings are reported for the Puget Sound region, where the temperature of the hottest (top 1%) days is projected to increase by +6.5°F, on average, by the 2050s and +9.8°F, on average, by the 2080s (Table 1).

Warming also results in less severe extreme cold events. City Light projects 24 fewer days (±5 days) with minimum temperature below 32°F by the 2050s. For the Puget Sound region as a whole, the temperature of the coldest (bottom 1%) nights increases by +5.4°F, on average, by the 2050s and +8.3°F, on average, by the 2080s (Table 1).

3 Projected change in the top 1% of daily maximum temperature. Projections are based on 10 global models and two greenhouse gas scenarios (RCP 4.5 and 8.5).
4 Projected change in bottom 1% of daily minimum temperature for climate scenarios described in Footnote 6 .
5 Raymond, C. 2016. Seattle City Light Climate Change Vulnerability and Adaptation Assessment. Seattle City Light, Environmental Affairs and Real Estate Division.
6 Changes for the SeaTac weather station for a high warming scenario, relative to the 1950 to 2006 average.

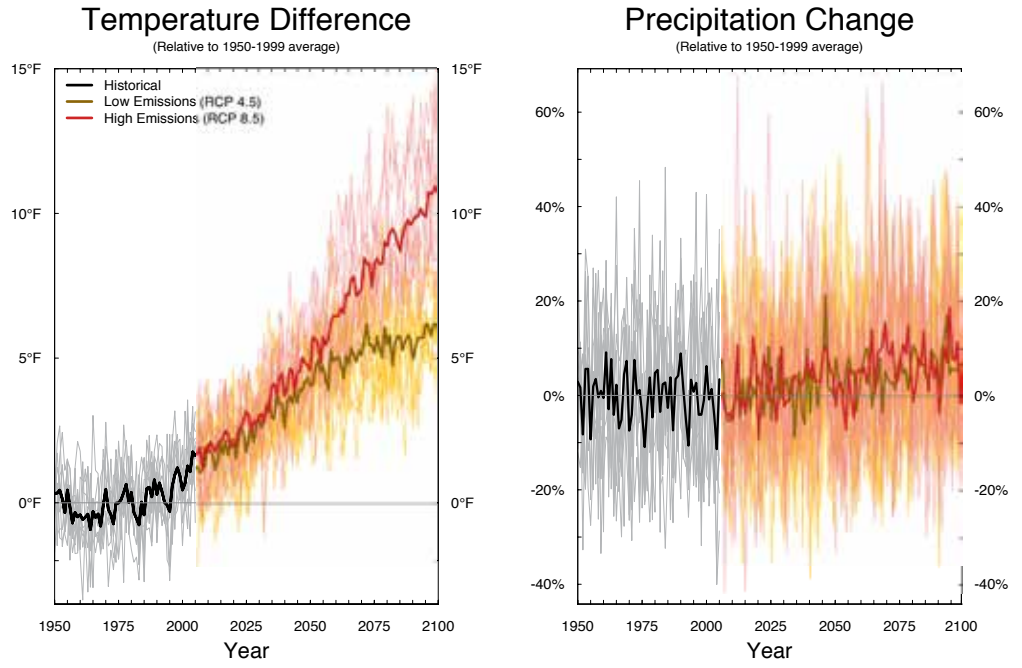


Figure 1. All Scenarios Project Warming in the Puget Sound Region for the 21st Century.

These graphs show average yearly air temperature (left) and precipitation (right) for the Puget Sound region, relative to the average for 1950-1999 (horizontal gray line, corresponding to an annual average temperature of 44°F and an annual total precipitation of 78 inches). The black line shows the average simulated air temperature or precipitation for 1950–2005, based on the individual model results indicated by the thin grey lines. The thick colored lines show the average among model projections for two emissions scenarios (low: RCP 4.5, and high: RCP 8.5), while the thin colored lines show individual model projections for each scenario. (Source: Mauger et al. 2015; Graphic: Mauger et al. 2015)

Continued variability in precipitation expected, but more extreme precipitation events

Climate change will also affect precipitation in the Puget Sound region, although the projected changes vary considerably. Most models project wetter fall, winter, and spring seasons (+3 to +11% on average for the 2050s, relative to 1970-1999) for a low and high greenhouse gas scenario. In contrast, models consistently project drier summers (−22% on average, for the 2050s). The net result of these seasonal changes is a relatively small increase in annual average precipitation (+4 to +5% on average, for the 2050s). While notable, the changes in seasonal and average annual precipitation may be difficult to distinguish from the region's large natural year-to-year variability in precipitation.

Changes in extreme precipitation are more significant. The heaviest (top 1%) 24-hour rain events in western Washington and Oregon are expected to be +22% more intense, on average, by the 2080s for a high warming scenario. The frequency of today's heaviest 24-hour rain events also increases, occurring eight days per year by the 2080s, on average, compared to two days per year historically (1970-1999). Unlike other changes in precipitation, the large changes projected for heavy precipitation events exceed the range of natural variability in precipitation shortly after mid-century.

A related concern is changes in extreme wind events. Preliminary research has found no clear trend in the frequency or intensity of extreme wind events over western Washington by the 2050s under moderate emission scenarios.[7] However, there is some indication that extreme wind events could shift earlier in the fall by as much as a week, increasing the chance that events occur when more leaves are on trees. Additional research is needed assess the robustness of these findings.

Sea level will rise

Sea level is projected to rise two feet, on average, in Seattle by 2100 (range of +4 to +56 inches, relative to 2000).[8] Although changes in storm surge are unclear at this time, a higher base sea level allows high tides and storm surge to reach farther inland, increasing the extent and frequency of coastal flooding. An initial analysis of sea level rise impacts by the City of Seattle[9] found that today's 100-year storm surge event becomes a monthly event by 2060 with 2 feet of sea level rise (Table 2). Similarly, today's annual high tide event becomes a daily high tide by 2060 with 2 feet of sea level rise.

	NOW	2035		2060	
	A	B	C = A + B	D	E = A+D
	Water Level*	Projected Sea Level Rise	Water Level	Projected Sea Level Rise	Water Level
100 Yr Storm (Surge)†	3'	1'	4'	2'	5'
Annually	2'	1'	3'	2'	4'
Monthly	1'	1'	2'	2'	3'
Daily	0	1'	1'	2'	2'

* Above average daily high tide (MHHW)

† Current projections do not show a change in storm surge as a result of sea level rise.

Table 2. Current and Projected Water Levels for the 100-Year Surge Event, Annual, Monthly, and Daily High Tides. Changes are based on a combination of projected sea level rise (+1 foot in 2035 and +2 feet in 2060) and the historical 100-year event storm surge (3 feet above the average daily high tide). Results are relative to the current average daily high tide (MHHW = 9.01 feet). (Source: National Research Council; Graphic: GGLO)

General Impacts of a Warming Climate

7 For the purposes of the study, an extreme wind event was defined as the 95th and 99th percentile events, which correspond to wind speeds of about 25 and 32 mph, respectively, at Seattle-Tacoma International Airport. Study results relative to relative to 1970-2000. From: Salathé, E., G. Mauger, C. Mass, R. Steed, and B. Dotson. 2015. Final Project Report: Regional Modeling for Windstorms and Lightning. Report prepared by the University of Washington Climate Impacts Group for Seattle City Light, Seattle, Washington.

8 Average based on a moderate warming scenario (A1B), relative to 2000. From: National Research Council. 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Committee on Sea Level Rise in California, Oregon, Washington. Board on Earth Sciences Resources Ocean Studies Board Division on Earth Life Studies The National Academies Press.

9 Climate Preparedness: A Mapping Inventory of Changing Coastal Flood Risk. Seattle Office of Sustainability, August 2015. Available at: http://www.seattle.gov/environment/climate-change/planning-for-climate-impacts

The changes in temperature, precipitation, and sea level projected for the Puget Sound region have wide-ranging impacts, including the following.

- **Increased risk of flooding and drought**. Warmer winter temperatures are expected to lead to lower winter snowpack and higher (and earlier) peak streamflows in watersheds that historically accumulated snowpack, including the watersheds used by Seattle for hydropower generation and municipal water supply. These changes simultaneously increase the risk of flooding and drought, and will require more active management of water resources to meet objectives for people and the environment.
- **Potential for more heat stress in urban environments**. Warmer summer temperatures and more extreme heat events can increase the potential for heat-related illnesses and death associated with cardiovascular, respiratory, cerebrovascular (e.g., stroke) diseases. Warmer and drier summers can also lead to higher summer water and energy demands, and may reduce asset life or performance.
- **Increased risk of landslides**. More winter precipitation can increase ground saturation, contributing to a higher risk of landslides, seepage around retaining walls and into underground vaults or other structures, and downed trees. Higher groundwater and more exposure to moisture can also increase corrosion and reduce asset life.
- **More difficulties with urban drainage**. More extreme precipitation can exacerbate drainage problems and lead to more urban flooding, landslides, and erosion. Where storm water and sewer systems are connected, more extreme precipitation increases the potential for combined sewer overflows. Finally, more extreme precipitation increases the risk of flooding in urban watersheds.
- **Increased drought stress**. Lower summer precipitation, combined with warmer summer temperatures, contributes to increasing drought stress for urban trees and landscaping. Additionally, lower summer precipitation will exacerbate summer low flows in urban streams. This can concentrate pollutants and lead to warmer water temperatures, both of which affect water quality and can create conditions that are more stressful for aquatic species.
- **Increased coastal flooding, erosion, and corrosion**. Sea level rise will lead to more frequent inundation of low-lying areas and may increase erosion, salt water intrusion, corrosion, and loss of valuable near-shore habitat. Sea level rise can also slow or block stormwater drainage into Puget Sound, leading to road closures, reduced access to facilities, and damage to public and private property.

Specific impacts and the implications of these impacts for the City of Seattle departments, programs, and services are summarized in the following sections.

EQUITY AND CLIMATE CHANGE

Environmental Justice and Climate Preparedness

> "The effects of climate change threaten everyone, but they do not threaten all people equally."
>
> - Jacqui Patterson, Director Climate Justice Initiative, NAACP

> "When disasters hit, nature does not discriminate. Unfortunately society does, and as a result climate impacts are not the same for all communities…. Generally, those who are most affected by climate change are not the people who are in charge of adaptation processes. It is important that these different groups work together to adapt to climate change. Without careful attention to issues of race and class, climate change adaptation measures run the risk of perpetuating or worsening social inequalities."
>
> - Sarika Tandon, WE ACT for Climate Justice Project
>
> Race, Vulnerability, and Differential Impacts: Prioritizing Social Justice in Climate Change Adaptation, 2013

Environmental Justice

> All historically disadvantaged groups – people of color, lesbians, gay men, people who are transgendered, women, people with disabilities, low-income households, to name a few – experience systemic inequity. Many people and communities live at the intersection of these identities, for example lesbians of color, experiencing multiple inequities at once. By centering on race and using tools that can be applied across oppressions, we increase the ability of all of us to work for equity.
>
> -Seattle Race and Social Justice Initiative

The legacy of institutional and systemic racism in our economic, government, and social systems has resulted – and continues to result – in the disproportionate distribution of the benefits and burdens of our society for people of color and lower income residents (often referred to as frontline communities). While frontline communities provide inspiring examples of resilience in the face of these injustices, racism has profound impacts on climate risk; therefore, racial equity must be incorporated as a foundation of climate preparedness planning. In order to foster more just climate preparedness and to avoid implementing strategies that exacerbate existing inequities, frontline communities should hold power in the development and implementation of preparedness actions.

> "…if communities of color are not engaged in climate resilience and are not represented in leading change, policy solutions will ultimately not reflect our interests."
>
> Got Green & Puget Sound Sage, Our People, Our Planet, Our Power, March 2016

Vulnerability to climate impacts is a function of exposure, sensitivity and the capacity to adapt to impacts. Systemic and institutional racism has resulted in increased sensitivity and more limited adaptive capacity among people of color, especially lower income people of color and immigrant and refugee communities. For example, frontline communities are more likely to be exposed to industrial pollution, live closer to busy roads (which are significant sources of air and noise pollution) and farther from effective public transportation, live and work in poorly constructed buildings and in areas subject to flooding, attend schools with fewer resources, and have limited access to high quality health care despite a higher prevalence of pre-existing health conditions. These factors increase the risk of negative impacts from climate change .for example, pre-existing health conditions like asthma and heart disease, which are more common in communities of color, can exacerbate the impact of heat waves and flooding may result in property damage which can be financially devastating to a lower income resident.

A significant contributor to these inequities, particularly for people of color, immigrants, refugees and people with limited English language proficiency, is disproportionate access to government decision making processes. Language barriers, lack of time, distrust in government, and poor access have precluded some voices from being heard and contributed to policy and investment decisions that result in an inequitable distribution of the burdens of climate change.

> "The voices of frontline communities, the ones that most impacted, usually don't make it to the airwaves."
> -Jacqui Patterson, Director, Climate Justice Initiative, NAACP

Toxic facilities, like coal fired power plants and incinerators, are emitting mercury, arsenic, lead, and other contaminants into the water, food, and lungs of communities. Many of these same facilities are also emitting carbon dioxide and methane – the #1 and #2 drivers of climate change. At the same time not all are equally impacted. For example, race – even more than class – is the number one indicator for the placement of toxic facilities in this country. And communities of color and low income communities are often the hardest hit by climate change.

http://www.naacp.org/programs/entry/climate-justice

Environmental justice will be achieved when

All people have access to the information that will enable them to participate fully in making decisions that affect their environment

All people are treated fairly and provided the opportunity for meaningful involvement with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies

All people have equal and fair access to a safe, healthy, and sustainable environment at home, at work, at school, and in public places

No racial, ethnic, or socioeconomic group or vulnerable population – such as children, the elderly or the disabled – suffers from a disproportionate share of negative environmental risks or burdens.

No group of people suffers from displacement and gentrification as a result of environmental remediation efforts.

- Environmental Justice League of Rhode Island http://ejlri.org/environmental-justice/our-mission/

In addition to those impacted by racism, other factors contribute to disproportionate climate risk. For example, people with disabilities may have difficulty evacuating during emergencies and may not be able to access decision-making processes, older residents have a higher risk

for pre-existing health conditions, and outdoor workers are at greater risk during heat waves. Please see Table 1, developed by Bay Localize, for a more detailed description of factors which contribute to climate vulnerability.

To advance equity, we must approach climate preparedness in way that addresses the underlying causes of disproportionate climate risk and transition to a community-centered planning model where those most impacted have power in the planning process.

Seattle's Disproportionate Climate Risk

Like other communities across the country, Seattle must address its own unique issues of disproportionate climate vulnerability. Climate impacts will be felt across the city, but the risk of negative outcomes from those impacts will vary from neighborhood to neighborhood, from block to block, and even from person to person. High temperatures on Queen Anne hill do not come with the same implications that accompany similar temperatures in the International District where air pollution levels increase the likelihood of negative impacts. Likewise, a flood in the lower Duwamish area where residents may have fewer resources to repair damages to their homes will affect residents differently than some higher income residents in West Seattle. Of the many climate impacts Seattle is expected to face, flooding and extreme heat have the greatest potential to result in disproportionate impacts. While a comprehensive analysis of the disproportionate impacts of climate change has not been conducted, examples of these impacts are explored below:

Sea Level Rise

The Seattle Mapping Inventory of Changing Coastal Flood Risk provides a screening level picture of the impacts of sea level rise on Seattle. The report provides an inventory of infrastructure, natural systems, and communities at risk of flooding under future conditions. To better understand the environmental justice implications of sea level rise, census tracts impacted by projected flooding were assessed according to social variables which consider factors such as income, age, minority status, disability, language, transportation accessibility, and housing situation. The analysis reveals that the communities most impacted by flooding are also disproportionately characterized by high levels of social vulnerability, most notably in South Park and Georgetown.

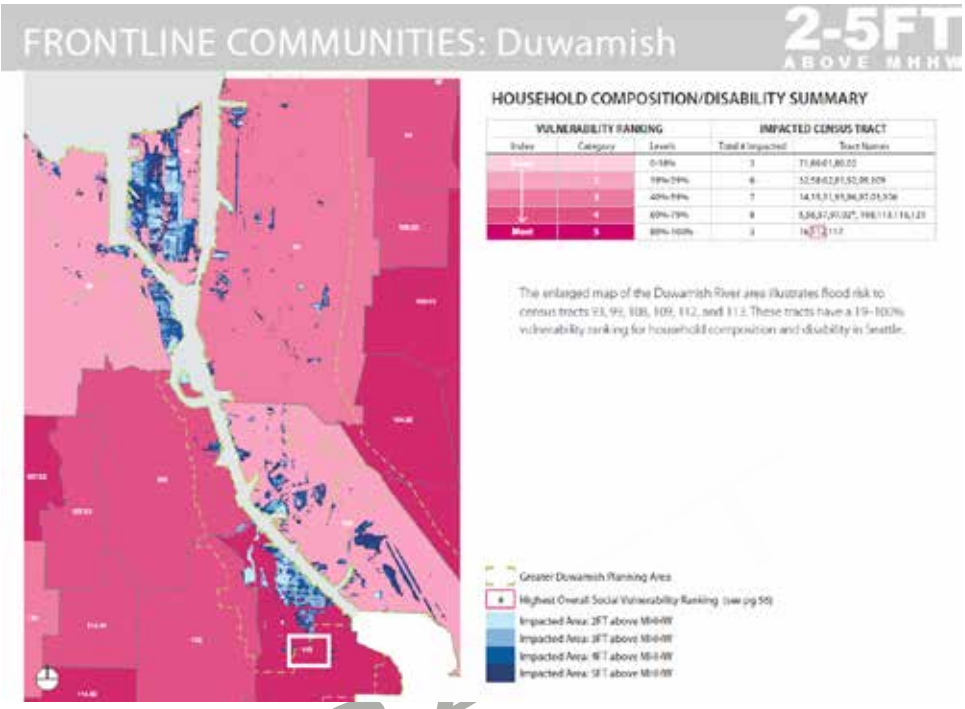


Figure 2. Frontline Communities: Duwamish . (Source: Mapping Inventory of Changing Coastal Floor Risk Report, Seattle Office of Sustainability & Environment. Graphic: GGLO)

Extreme Heat

Climate change is projected to increase the frequency, intensity and duration of extreme heat events, which will exacerbate health impacts particularly in areas with higher air pollution levels. The Puget Sound Clean Air Agency has identified "highly impacted communities" - geographic locations within their four county jurisdiction that are characterized by degraded air quality and whose residents face economic or historic barriers to participation in clean air decisions and solutions based on criteria that are relevant to air quality, health, and demographic markers. The International District/Chinatown and the lower Duwamish neighborhoods of South Park and Georgetown were identified and designated as two of the Agency's priority Highly-Impacted Communities[1].

Seattle's Environment & Equity Agenda

Recognizing the potential for government action to either perpetuate or address environmental injustice in our society, the City of Seattle launched the Environment & Equity Initiative (EEI): a partnership of the City, the community and several private foundations created to deepen Seattle's commitment to race and social justice in environmental work. The EEI seeks to advance the following goals:

- All people and communities benefit from Seattle's environmental progress.

1 http://www.pscleanair.org/library/Documents/HI-C_Report_pscleanair_20150415.pdf

- Communities most impacted by environmental injustice are engaged in setting environmental priorities, designing strategies, and tracking progress.
- People of color, immigrants and refugees, people with low incomes, and limited-English proficiency individuals have opportunities to be part of and leaders in the mainstream environmental movement.

The cornerstone of the EEI is the Environmental Action Agenda which was jointly developed by the City and the community through the Community Partners Steering Committee and with extensive community participation. The Environmental Action Agenda includes short- and long-term actions to advance equity and environmental justice, and increase capacity for those most-affected by environmental issues to lead in the development and implementation of solutions.

The Agenda was informed by an Environmental Equity Assessment to evaluate how equitably environmental impacts and outcomes are distributed in Seattle. The Assessment explores both quantitative and qualitative data that together begin to describe the landscape of environmental equity in Seattle. The Assessment identified:

- EEI Focus Areas - geographic areas highly impacted by socioeconomic and environmental challenges.
- EEI Populations – communities of color, immigrants and refugees, people with low incomes and limited English proficiency individuals.
- The EEI goals, the Environmental Action Agenda, the EEI focus areas and populations will inform the implementation of this Strategy.

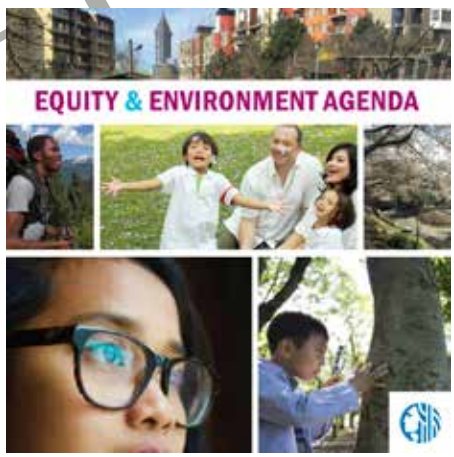


Figure 2. Equity & Environment Agenda Report
(source: City of Seattle)

Embedding Equity as the Foundation of Preparedness Planning

In order to reduce disproportionate climate risk and help ensure that the benefits and burdens of preparedness strategies are equitably shared, climate change preparedness strategies should:

- Prioritize actions that support communities of color and lower income communities, as well as people with disabilities and older residents, moderate potential impacts and cope with the consequences of climate change which requires addressing the underlying causes of disproportionate climate risk.
- Empower frontline communities as leaders in the planning process, which will require rebuilding trust in government that has been eroded as a result of systemic racism and classism.

Preparedness

ACTION

1. Develop an equitable climate preparedness planning and evaluation tool that will better enable understanding of the underlying causes of disproportionate impacts and strategies to address those impacts.
2. Apply the tool when planning and designing preparedness strategies.
3. Prioritize EEI Focus Areas and Populations when designing implementation strategies.
4. Design planning processes to include community as partners, sharing decision-making power.
5. Foster social cohesion, a key factor in community resilience, through engagement and planning processes

	Major Vulnerability Factors to Climate Impacts
Income	Low-income residents are more likely to face related factors including lack of air conditioning in hot climates, renting homes versus owning them, lack of citizenship status, lack of insurance (health, life, or property), lack of a high school diploma and lack of access to a vehicle to evacuate.
Language Barriers	Inability to understand and speak English can be a barrier in receiving information about climate change and its impacts, getting involved with climate adaptation planning processes, understanding emergency announcements and instructions, or handling paperwork in applying for relief benefits.
Racism	Institutionalized racism imbedded in many social systems including zoning, infrastructure spending, access to neighborhood amenities, and quality of emergency response create disproportionate risk for people of color to most impacts of climate change.
Health Conditions & Disabilities	Asthma patients suffer more attacks in poor air quality resulting from increased ozone in heat waves or smoke from wild fires. Heart disease increases risk of mortality in heat waves. Limited mobility makes evacuation difficult. Residents who rely on electricity to refrigerate medications or to run medical appliances are at risk during power outages.
Age	Young children and the elderly (especially those living on their own) can be more susceptible to health problems from impacts such as heat waves, especially if they also suffer from health conditions. Pregnancy is also a risk factor in emergencies.
Living Conditions/ Location (Housing or Workplace)	Vulnerable locations include floodplains, areas with poor air quality, risks of wild fires or landslides, lack of trees and parks, high crime, or geographic isolation. Vulnerable conditions include buildings with poor construction or inadequate cooling systems, living in an institution (affects ability to evacuate, especially for incarcerated populations), renting versus owning a home, and homelessness.
Occupation	Residents who work outside during extreme weather, such as farmworkers or construction workers, are at disproportionate risk for mortality from heat waves.

Table 1. Major Vulnerability Factors to Climate Impacts. (Sources: Cooley et al. (2012), Jerrett et al. (2012), and Morello-Frosch et al. (2008), Bay Localize: Equity and Resilience)

STRATEGY OVERVIEW

STRATEGY OVERVIEW

Each section within the following Sector-Specific Actions chapter provides an overview of the impacts of climate change on assets and programs and a list of priority actions to be taken over the next five years. The actions are excerpted below:

Transportation	
Planning & Development	• Develop a mechanism to consider future climate conditions in capital project siting and design. • Consider the disproportionate impacts of climate change on people of color, lower income residents, and people with disabilities when prioritizing projects. • Apply the Sea Level Rise Planning Guidance to capital projects in areas projected to impacted by sea level rise.
Pavement	• Increase the use and frequency of preventive maintenance (e.g. seal coats, crack seals). • Adjust pavement materials specifications over time to account for increasing summer temperatures. • Identify areas prone to high groundwater and flooding, and needed changes to roadway subgrades and drainage facilities; prioritize action in EEI Focus Areas.
Structures	• Refine SDOT's vulnerability assessment methodology to more accurately identify climate change risks to structures and update project prioritization accordingly, also considering EEI Focus Areas. • Identify increased operation and maintenance costs for bridges due to changes in heat, flooding, and abutment erosion. • Continue identifying long-term solutions for heat related issues (e.g. increasing ventilation in signal control boxes) and consider upgrading expansion joints and other key features of structures as part of ongoing maintenance.
Conveyance Systems	• Review capacity of existing standard conveyance system design based on increased precipitation projections. • Collaborate with SPU to develop a strategy to reduce chronic flooding, especially on major transit routes.
Trees	• Continue to research and update the approved street tree list to reduce risks related to heat and increased precipitation on street trees, including identifying species that can be used in areas where flooding and/or high groundwater may occur and species • Prioritize tree planting and other natural systems strategies to reduce heat islands, buffer pollution sources, prioritizing neighborhoods with poor air quality and higher levels of health issues. • Improve tree maintenance, including increasing the tree establishment period from 3 years to 4 years, reducing maintenance cycles for established trees, and extending the watering season. • Launch a community campaign to increase support for tree planting and care, include information about how trees are part of the city's goals for climate. • Develop an SDOT Urban Forest Master Plan, including an updated street tree inventory. • Assess the costs and benefits of transitioning all street tree care to SDOT, including potential funding mechanisms.

Land Use & the Built Environment	
Planning and Programmatic Actions	• Mitigate the urban heat island effect through programs that cool the urban environment, including planting and maintaining trees and employing green infrastructure. • Explore further opportunities to incentivize or require existing building upgrades to improve preparedness for future climate conditions. • Develop mechanisms to incorporate climate preparedness and passive survivability into the planning and development processes for new development. • Consider the disproportionate impacts of climate change on communities of color and lower income communities in planning, policies, and programs, and prioritize programs and incentives that mitigate those impacts.
Flood-Related Regulations & Programs	• Evaluate the benefits and costs of participating in the National Flood Insurance Community Rating System program. • Evaluate the requirements of the Floodplain Development Ordinance to identify additional A57 opportunities to reduce flood hazards, including the base flood elevation threshold, the definition of a substantial improvement, and the regulation of footbridges and • Regularly update flood prone area maps to incorporate the latest data near creeks, shorelines, and other emerging urban flooding areas. • Conduct a detailed coastal study of the Duwamish River to better delineate the current and increasing risk of flooding and identify a range of mitigation strategies. • Assess the benefits of incorporating rolling easements into the next update of the Shoreline Master Plan. • Continue to incorporate Green Stormwater Infrastructure (GSI) into development regulations. • Evaluate options to encourage or require significant on-site rainwater storage, both to mitigate the impact of heavy rainstorms on the City stormwater system and to provide non-potable water for irrigation and toilet flushing.
Landslide Hazard Areas	• Maintain a citywide repository for landslide data, including the locations and dates of slides, and observations about factors that may have contributed to their occurrence. • Update the Seattle Public Utilities Landslide Study to reflect current and projected climate conditions. • Evaluate mechanisms to support private property owners in making drainage improvements on their property in landslide prone areas, prioritizing the needs of communities of color and lower income residents in the analysis.
Energy Management & Cooling	• Evaluate code mechanisms to encourage or require new and renovated buildings to minimize the energy required to operate the building under extreme weather conditions or power loss, particularly using passive building envelope strategies • Evaluate current ASHRAE cooling temperature design standards to ensure they are sufficient to meet future temperatures that are projected to impact cooling peaks and durations. • Encourage the use of shade and green roofs to reduce heat island effect while providing comfortable exterior environments. • Support the near-term adoption of energy efficiency, electric heat pumps, insulation, and good windows which reduce energy needs in both winter and summer, and heat pumps to and high performance systems as home energy upgrades occur to both improve • Identify opportunities to support the near- term adoption of electric heat pumps and high performance systems in buildings used as community gathering spaces, particularly in communities of color and lower income communities EEI focus areas to improve energy

City Buildings & Public Spaces	
Buildings and Public Spaces	• Evaluate facility design standards against projected future climate conditions including heat load transfer, drainage infrastructure, and overhangs. • Include more shade trees in facility design, where possible, to help reduce building temperatures and to provide shade for the public while using facilities. • Assess the need for passive and active cooling and resilience retrofits by considering the impacts of increasing heat events and higher nighttime temperatures on operations and maintenance budgets. • Evaluate City facilities in areas at risk of landslides and floods prone assets including the likelihood and consequences of additional climate-related impacts to these properties and identify additional actions to enhance resilience

Parks	
Property & Buildings	• Conduct an asset management audit of landslide and flood prone assets. Identify the likelihood and consequences of climate related impacts to these properties and prioritizes subsequent actions with the asset management program. • Coordinate with other City departments to reduce off-site factors that may exacerbate risks to parks and recreation assets, such as stormwater management facilities in parks properties operated and maintained by SPU. • Strengthen Parks' emergency management response capabilities through actions, which may include increased stockpiling of supplies, confirming building systems are adequate).
Pavement	• Integrate SDOT's findings for pavement specifications into DPR standard specifications and details. • Where Parks-managed streets serve transit, consider prioritizing investment, repair, and maintenance to busy transit corridors.
Structures	• Identify locations and vulnerability of structures (e.g. retaining walls, sea walls, staircases, and bridges) that may require retrofit due increases in high intensity rain events and coastal flooding and develop a strategy for mitigation risks, prioritize locations in EEI focus areas. • Coordinate with other City agencies to reduce any off-site factors that may exacerbate risks to parks and recreation assets, such as working with other departments to enforce illicit drainage discharges onto Parks land. • Identify increased operation and maintenance costs for bridges due to changes in heat, flooding, and abutment erosion. • Work with first-responders to identify key routes for emergency vehicle access that may be compromised by structure failures. • Increase training for staff around erosion, sediment, landslides, risk identification, and management.
Conveyance Systems	• Audit existing Parks-owned and managed catch basins and outfalls, review capacity of existing standard drainage structures based on increased precipitation • Work with first-responders to identify key routes for emergency vehicle access that may be compromised by flooding from inadequate catch basins or areas without drainage infrastructure. • Continue to collaborate with SPU and other city agencies to reduce chronic flooding that reduces the usability and/or safety of parks.

Parks	
Trees & Vegetation	• Continue to research and modify the approved tree list to reduce risks related to heat and increased precipitation, including identifying species that can be used in areas where flooding and/or high groundwater may occur and species appropriate for anticipated • Prioritize tree planting and other natural system strategies to reduce heat islands, mitigate storm surges, buffer pollution sources in communities with demographics which indicate higher levels of pre-existing health conditions and other susceptibility to the • Increase stewardship capacity and protocols to better maintain existing vegetation and restore the urban forest. • Due to increased stressors, increase the tree establishment period from 3 years to 4 years. • Evaluate using technology to inform watering decisions in order to more efficiently use existing water resources. Consider increasing the watering season as summer drought conditions last longer. • Evaluate options for using non-potable water for watering. • Evaluate the budget implications of additional watering/establishment care, storm/drought maintenance, and tree removal and replacement.

Drainage & Water Supply Systems	
Drainage	• Complete a comprehensive climate adaptation and strategy identifying and evaluating a portfolio of innovative approaches to managing stormwater. • Develope predictive analytics that enhance the ability to anticipate and prepare for the potential impacts from storms. • Conduct a threshold analysis of the sewer network to determine sensitivity to different types of storm events. • Analyze the combined effects of sea level rise and extreme rainfall events would have on the drainage network in several tidally influenced basins. • Update the Intensity, Duration, Frequency (IDF) curves used by stormwater infrastructure designers to inform the sizing of new infrastructure. • Update departmental policies to better incorporate consideration of climate impacts into decision making. • Integrate consideration of climate change impacts into the Stage Gates process, the governance system that helps SPU make informed decisions about the planning, selection and delivery of projects and programs. • Continue to invest in GSI.
Water Supply	• Identify and assess the utility of adaptation options in offsetting climate impacts on supply and demand (to be completed in 2017). The climate impacts and adaptation analysis will be included in SPU's next update of its water system plan, which is due in 2019. • Assess the vulnerability of our forested watersheds to fire and develop a strategy to address that vulnerability. • In partnership with the Cedar River Habitat Conservation Plan (HCP) Oversight Committee, exploring how to extend our climate analysis to assess potential climate impacts on fisheries of concern in the Cedar River.

Electricity System	
Shoreline Infrastructure	• Make spatial information on projected sea level rise and more frequent coastal flooding readily available to all divisions of Seattle City Light for use in planning for facilities and equipment located near Puget Sound. • Consider the potential effects of sea level rise and more frequent coastal flooding on facilities through the facilities master planning process for the South Service Center. • Develop a process through which new large projects and facilities can be evaluated for potential impacts of sea level rise and coastal flooding within the life expectancy of the project or facility. • Update and expand Seattle City Light's assessment of the long-term effects of warmer temperatures (winter and summer) on load by including climate change scenarios in load forecasting and the Integrated Resource Plan. Develop a process to evaluate potential effects of these changes in demand on revenue
Electricity Demand	• Update and expand Seattle City Light's assessment of the long-term effects of warmer temperatures (winter and summer) on load by including climate change scenarios in load forecasting and the Integrated Resource Plan. Develop a process to evaluate potential effects of these changes in demand on revenue. • Research potential long-term effects of warmer summer temperatures and extreme high temperatures on summer load peaks and changes in residential air conditioning use in the service area.
Transmission & Distribution	• Increase capacity of Seattle City Light employees to prepare for and respond to wildland fire risks through additional education, wildland fire training, and mutual aid agreements. • Continue to participate in the Firewise program to increase knowledge and capacity to prepare for wildland fires at the Skagit Hydroelectric Project. • Continue to pursue actions and grant opportunities to upgrade infrastructure with fire-resistant materials and enhance fire protection and response equipment and capability at the Skagit Hydroelectric Project and the towns of Newhalem and Diablo. • Collaborate with resource management agencies and the Skagit Conservation District to research the most effective and environmentally responsible ways to implement vegetation treatments to reduce wildland fire risk. • Collaborate with adjacent land owners to reduce flammable vegetation and wildland fire risk along transmission lines and near critical infrastructure at the hydroelectric projects, including efforts to increase defensible space around facilities and buildings in Diablo and Newhalem • Collaborate with state resource management agencies and academic institutions to map landslide risk along transmission line rights-of-way and critical access roads, including research on the effects of heavier precipitation on existing landslide risk. • Evaluate increasing erosion and flood risk to transmission towers along the Skagit transmission line, with an emphasis on understanding the additional risk posed by higher peak flows.
Hydroelectric Project Operations	• Update Seattle City Light's assessment of how operations of the Skagit Hydroelectric Project may be affected by changes in streamflow using the latest research funded by the utility's Climate Initiative. Projected impacts on hydropower generation (and other objectives of the project) will be used to inform Integrated Resource Plans and potential actions to address climate change in the FERC relicensing process. • Update Seattle City Light's assessment of how operations at the Boundary Hydroelectric Project could be affected by changes in streamflow using the latest research from the Joint River Management Operating Committee II (RMJOC II). In 2016, the RMJOC II will complete a study on the effects of climate change on the Columbia River Basin hydroelectric system. This research can be used to evaluate effects on the Boundary Hydroelectric Project and BPA hydropower purchases. • Collaborate with Seattle Public Utilities to assess the effects of changes in streamflow on operations of the South Fork Told and Cedar Falls Hydroelectric Projects. Consider this information in long-term planning for the Cedar Falls Hydroelectric Project.

Electricity System	
Fish Habitat Restoration & Protection	• Consider increases in peak streamflow (fall/winter), lower streamflow (spring/ summer), and warmer stream temperatures in prioritizing land acquisitions for fish habitat mitigation lands. • Consider increases in peak streamflow (fall/winter), lower streamflow (spring/ summer), and warmer stream temperatures in objectives and design of restoration projects on fish habitat mitigation lands. • Collaborate with federal, state, and tribal resource management agencies to directly address climate change impacts on fish populations and habitat in recovery planning for fish species listed under the Endangered Species Act.

Community Preparedness	
Emergency Planning	• Continue to factor climate change projections into emergency preparedness and recovery planning, including future updates to the Seattle Hazard Identification and Vulnerability Analysis, the Seattle Comprehensive Emergency Management Plan and the Disaster Recovery Framework. • Strengthen capabilities of individuals, households, neighborhoods, businesses and organizations that assist in disaster response to prepare for potential climate change impacts, including disproportionate impacts on frontline communities through participatory planning, training, educational materials, and volunteer development. • Recognize that disaster impacts will increase as a result of climate change, especially in frontline communities, and incorporate the changes in emergency plans and in programs designed to increase community resilience. • Develop and distribute culturally appropriate and accessible materials about the impacts of climate change and how individuals can prepare. • Evaluate the potential for solar/storage projects to support critical facility operation during extreme events when the grid power supply is not available.
Extreme Heat Event Response	• Evaluate the temperature thresholds that trigger the City's heat response to ensure they adequately account for weather conditions, factors impacting indoor building temperatures (e.g. materials, orientation, etc.), and frontline communities. • Facilitate access to safe and cool spaces during extreme heat events prioritizing frontline communities (the elderly, people of color and lower income residents. • Conduct outreach to prevent animals from being left in cars unattended on days with high temperatures. • Provide training for public safety staff in recognizing and responding to the physical and behavioral signs of heat-related illness. • Support installation of heat pumps to provide cooling where most needed.
Food Systems	• Strengthen the local and regional food system by implementing the Seattle Food Action Plan and consider the impacts of climate change on access to healthy, affordable food in future Plan updates. • Expand community gardening and urban agriculture opportunities at P-patches, schools and available vacant land. • Continue efforts to preserve farmland near the city through land use and Transfer of Development Rights policies. • Provide support for safety-net programs including food banks, meal programs, summer lunch, and Fresh Bucks, which can provide needed access to healthy food for low-income residents in the case of rising food prices.

SECTOR-SPECIFIC ACTIONS

Introduction

While we must make concerted efforts to reduce greenhouse gas (GHG) emissions, historic emissions have and will continue to impact the global climate. Additionally, the lack of progress in reducing future emissions means that additional climate change will exacerbate the impacts communities are already experiencing.

Flooding, heat waves, and extreme high tides are not new challenges in Seattle, and we have strategies for responding to them. However, climate change will shift the frequency, intensity, and timing of these events, and what we now consider an extreme event will become the new normal.

Cross-sector issues related to climate change, with particular attention to frontline communities including: social; economic; health and ecosystem services were addressed in an integrated approach.

Strategic Categories

Preparing for climate change actions are organized into the following categories:

- Transportation
- Land Use & the Built Environment
- City Buildings
- Parks
- Drainage & Water Supply Systems
- Electricity System
- Community Preparedness

TRANSPORTATION

Background/Context

The Seattle Department of Transportation (SDOT) develops, maintains, and operates the city's transportation system including[1]:

- Nearly 4,000 lane-miles of streets,
- 117 bridges,
- 509 stairways,
- 582 retaining walls,
- 257 traffic cameras,
- 1,071 signalized intersections,
- 40 miles of bike trails,
- 338 miles of on-street bicycle facilities,
- ~250,000 street trees, ~41,000 of which are maintained by SDOT,
- 2,022 paid on-street parking stalls,
- 29,073 curb ramps,
- More than 181,000 signs, and
- 123 acres of SDOT managed landscape areas.

In total, these assets have a replacement value of about $20 billion and are vital to mobility for Seattle residents and visitors.

Based on a series of interviews with SDOT staff and research about potential climate impacts on transportation systems, the following transportation asset classes were identified as the most vulnerable:

- Pavement
- Structures (bridges, retaining walls, etc)
- Stormwater Conveyance Systems
- Street Trees

Much of Seattle's infrastructure was constructed in the first half of the twentieth century and was not designed for today's service needs. The age of our infrastructure combined with historic deferred maintenance increases the transportation system's vulnerability to climate change. For example, many of the City's most heavily traveled streets suffer from pavement degradation caused by heavy vehicle loading and a lack of historic maintenance. Additional heat (which softens the asphalt) or precipitation (which can saturate and weaken the subgrade) further hastens pavement degradation and can result in pavement failure even sooner than anticipated.

1 2015 Status and Condition Report, "SDOT Transportation Infrastructure Assets," http://www.seattle.gov/transportation/inventory.htm

The table below details potential climate change impacts on assets and potential implications for operations and maintenance and the users of the infrastructure. It is important to note that increased deterioration of infrastructure may increase costs damage claims and associated costs.

SDOT Asset Class	Climate Impacts and Implications	
	Impacts on Assets	Implications for Operations and Maintenance
Pavement	*Increased potential for*: • Degradation of roadway including joints, asphalt softening, road/sidewalk buckling, and pavement. • Weakening of roadway subgrade support in areas affected by higher precipitation and ground/tidal water levels. • More frequent periods where summer temperatures prohibit concrete placement. • Erosion of soils, bluffs, and other features adjacent to pavement.	*Increased potential for*: • More frequent pavement maintenance, including more frequent seal coating, micro-surfacing, slurry seals, and other maintenance practices; more frequent pavement replacement due to reduced asset life. • Public safety issues where pavement deterioration creates walking, biking, or driving hazards. • Lengthening of the current paving and painting season due to warmer temperatures and drier summers.
Structures	*Increased potential for*: • Landslides in areas with unstable slopes. • Erosion of soils, bluffs, riverbanks/ beds, and other features adjacent to structures. • Retaining wall damage due to higher soil moisture loads, • Bridge expansion joint failure which may prevent movable bridges from closing. • Overtopping of older seawalls (newer seawalls and other structures have been designed to accommodate projected sea level rise	*Increased potential for*: • More frequent and/or longer duration road closures where structures are affected by landslides and erosion. • More frequent deployment of emergency response crews to deal with landslides/ erosion issues/bridge heat expansion issues. • Increased maintenance and monitoring needs to address erosion, flooding, and heat-related bridge impacts. • Public safety issues where slides, erosion, and other structural impacts occur. • More frequent replacement of assets due to reduced asset life or added capital costs to retrofit or replace existing assets. • Lower maintenance costs related to snow/ ice removal. • More construction and storm closures/ delays that impact transportation users.

ELLIOTT BAY SEAWALL PROJECT: If the highest predicted sea level rise were to occur, the current seawall elevation would be three feet above the new still water level. Based on the projections taken into account, SDOT does not anticipate it being necessary to build a higher structure to accommodate sea level rise over the next 100 years. The seawall is being designed to use drainage structures to reduce the risk of inundation by tidal backwater during extreme high water events, such as a storm surge at high tide. (Source: SDOT)

SDOT Asset Class	Climate Impacts and Implications	
	Impacts on Assets	Implications for Operations and Maintenance
Conveyance Systems	*Increased potential for*: • Stormwater overflow from undersized catch basin pipes. • Failure of larger drainage structures including roadway detention facilities. • Ponding and flowing water within public rights-of-way. • Combined sewer backups and overflows.	*Increased potential for*: • More frequent and/or longer duration lane restrictions or road closures where drainage impedes usage. • More frequent deployment of emergency response crews to deal with drainage issues. • Public safety issues where drainage problems exist.
Trees	*Increased potential for*: • Tree stress and mortality related to drought, insects, disease, and storms. • Downed limbs and trees related to more extreme precipitation and potential shifts in storms.	*Increased potential for*: • Longer annual watering seasons and the need to extend the watering period for new trees beyond the current 3-year establishment window. • Storm-related tree damage and related road closures and response costs. • Drought-related tree maintenance including fallen branches and dead tree removal • More tree maintenance to reduce the risk of tree blowdown or limb breakage during storms and droughts. • Damage to sidewalks due to root-heaving of drought-stressed trees.

Table 1. Climate Impacts and Implications: Transportation

Below, potential impacts and vulnerabilities of other transportation assets and operations are highlighted.

- Trip Reduction: Increased summer temperatures and more heat events may make it harder for people to walk or bike to transit, and affect rider comfort while using bus services. Increased summer temperatures may also suppress the level of walking and biking during summer heat waves, increasing driving.
- Street Car: Rail used for the street car should be designed and installed for anticipated temperature changes.
- Vehicle Fleet & Equipment: Increased summer temperatures may necessitate on-site air-conditioned vehicles or trailers for field employees.
- Control Boxes: More extreme heat events can lead to overheating of traffic control cabinets and signals (i.e., electronic devices managing right-of-way) resulting in signal outages. The cabinets can overheat when internal temperatures exceed 100°F. Existing cabinets are being retrofitted with two fans,.
- Vaults: More rain, particularly more extreme rain events, can lead to electronic malfunctions

in vaults that do not have adequate drainage. Underground connections in older concrete boxes are more vulnerable to this problem due to their tendency to have poor drainage (whether by pump or gravity). While SDOT no longer installs underground electrical vaults, older equipment may be susceptible to inundation. This may also be an issue in low-lying areas subject to more high-tide flooding events with higher sea levels.

Adaptation Strategies

VISION

The impacts of climate change on the transportation system are understood and planned for and the benefits of adaptation measures and burdens of climate change are equitably shared, including consideration of transit dependent communities and those with higher levels of air pollution.

Project Planning & Design

ACTIONS

1. Develop a mechanism in the project development and engineering process to consider future climate conditions, including changes to temperature, precipitation, and sea level, when siting and designing capital projects to ensure infrastructure functions as intended over its planned lifespan.
2. Consider the disproportionate impacts of climate change on people of color, lower income residents, and people with disabilities when prioritizing projects.
3. Apply the Seattle Sea Level Rise Planning Guidance for Capital Projects review process, or equivalent approach, to capital projects in areas projected to be impacted by sea level rise.

Pavement

ACTIONS

1. Increase the use and frequency of preventive maintenance treatments that would address accelerated pavement wearing (e.g., seal coats, crack seals).
2. As part of the regular review of new paving materials technology, identify potential adjustments to pavement materials and equipment/materials specifications to account for increasing summer temperatures. Update requirements for both public and private projects within the public rights-of-way accordingly.
3. Identify areas that may be more prone to high groundwater and flooding. Identify needed changes to roadway subgrades and drainage facilities in these areas to maximize the function and lifespan of the assets. Prioritize action in EEI focus areas.

Structures

ACTIONS:

1. Refine SDOT's vulnerability assessment methodology to more accurately identify climate change risks to structures (including but not limited to bridges, walls and vaults) and update project prioritization accordingly also consider EEI focus areas and populations.
2. Identify increased operation and maintenance costs for bridges due to changes in heat, flooding, and abutment erosion.
3. Continue identifying long-term solutions to heat related issues (e.g. increasing ventilation in signal control boxes) and consider upgrading expansion joints and other key features of structures as part of ongoing maintenance programs.

Conveyance Systems

ACTIONS:

1. Review capacity of existing standard conveyance system design based on increased precipitation projections.
2. Collaborate with Seattle Public Utilities to develop a strategy to reduce chronic flooding that reduces travel lane capacity, especially on major transit routes and for updating requirements for the conveyance system in areas at risk of impacts from flooding due to precipitation and sea level rise.

Trees

ACTIONS

1. Continue research and update the approved street tree list to reduce risks related to heat and increased precipitation on street trees, including identifying species that can be used in areas where flooding and/or high groundwater may occur and species appropriate for anticipated temperature changes.
2. Prioritize tree planting and other natural system strategies to reduce heat islands, buffer pollution sources prioritizing neighborhoods with poor air quality and higher levels of health issues, including Chinatown/International District, South Park and Georgetown.
3. Improve tree maintenance, including increasing the tree establishment period from 3 years to 4 years, reducing maintenance cycles for established trees, and extending the watering season. (create a side bar about the importance of proactive care to reduce potential hazards from limb fall, tree failure)

4. Launch a community campaign to increase support for tree planting and care, include information about how trees are part of the city's goals for climate.
5. Develop an SDOT Urban Forest Master Plan, including an updated street tree inventory.
6. Assess the costs and benefits of transitioning all street tree care to SDOT, including potential funding mechanisms.

LAND USE & THE BUILT ENVIRONMENT

Background/Context

The City of Seattle plans for and regulates land use and development. Land uses are set through community planning, the Comprehensive Plan, the Energy Benchmarking and Mandatory building tune-ups, Zoning Code, Environmental Critical Area regulations, and the Shoreline Master Program. Buildings are further influenced through building and energy codes, design review and permit processes, incentives and assistance programs for energy and water conservation. Together, these tools help protect shorelines and steep slopes and ensure buildings provide adequate protection from climatic elements like precipitation and temperature.

EXAMPLES OF THE CITY'S ROLE INFLUENCING DEVELOPMENT

Examples of the City's role influencing development include:

Flood-related activities:

- Coastal development standards
- Mapping flood prone areas
- Regulating development in flood prone areas
- Shoreline Master Program
- Green Stormwater Infrastructure Plan
- Stormwater Code

Slopes and landslide protection activities:

- Habitat management and tree protection
- Mapping steep slopes and assessing landslide risk
- Regulating development and stormwater discharges on or near steep slopes
- Building energy management
- Building energy codes
- Energy efficiency incentive programs
- Energy Benchmarking and Mandatory building tune-ups

Climate Change Impacts and Implications:

The city's built environment will become increasingly vulnerable to the impacts of climate change. City policies, plans, regulations, and processes provide an opportunity to enhance the resilience of neighborhoods and buildings, particularly in areas prone to flooding and landslides, in building energy and water management as temperatures increase and summer droughts lengthen.

The table below details potential climate change impacts on the built environment and opportunities to enhance resilience through plans, programs, and regulations.

Increased potential for:	Impact on City Plans, Programs, and Regulations
Flooding • Flooding at higher elevations • More frequent flooding • Damage to buildings	Maps that identify flood prone areas and trigger flood regulations may require updating, especially near creeks, shorelines, and other emerging urban flooding areas such as low points in topography (closed contours).
	Increased risk of water seepage and mold in buildings from flooding.
	Impacts to habitat near streams.
Landslide Hazards • More frequent landslides • Increased frequency of maintenance	Impacts to habitat on or near slopes.
	Risks to property near slide areas from slope destabilization.

Increased potential for:	Impact on City Plans, Programs, and Regulations
Energy Management & Cooling • Increased demand for active and passive cooling	Increased demand on summertime energy loads. Where cooling towers are used for air conditioning, water use may also increase.
• Increased demand for energy, where air conditioning is provided, where cooling towers are provided, this may increase water use • Increased heat-island effect	ASHRAE-established cooling design temperatures are based on historic temperatures, and may not reflect future temperature conditions.

Table 1. Climate Impacts and Implications: Land Use & the Built Environment

Adaptation Strategies:

VISION

Buildings and neighborhoods are planned, designed, and constructed to be resilient to the impacts of climate change while moving toward the City's goal of achieving carbon neutrality by 2050. Policies and programs should ensure an equitable distribution of benefits and burdens.

Planning and Programmatic Actions:

ACTION

1. Mitigate the urban heat island effect through programs that cool the urban environment, including planting and maintaining trees, increasing green space, and employing green infrastructure, particularly in EEI focus areas.
2. Explore further opportunities to incentivize or require existing building upgrades to improve preparedness for future climate conditions. This may include improvements to passive or active building cooling, energy storage, daylighting, flood protection, stormwater management, and passive survivability.
3. Develop mechanisms to incorporate climate preparedness and passive survivability into the planning and development processes for new development, including zoning, building codes, design review and permitting.
4. Consider the disproportionate impacts of climate change on communities of color and lower income communities in planning, policies, and programs, and prioritize programs and incentives that mitigate those impacts.

TUNE UPS

The Building Tune-Ups ordinance phases in a periodic (every 5 years) tune-up requirement for commercial buildings 50,000 square feet or larger, beginning in 2018. Tune-ups identify and correct no- or low-cost changes to building operations, measures that would pay back in 2-3 years. Exemptions take into account buildings that already conduct tune-ups or demonstrate high performance

Flood-Related Regulations & Programs

ACTION

1. To reduce flood risk and reduce flood insurance rates, evaluate the benefits and costs of participating in the National Flood Insurance Community Rating System program.
2. Evaluate the requirements of the Floodplain Development Ordinance to identify additional opportunities to reduce flood hazards, including the base flood elevation threshold, the definition of a substantial improvement, and the regulation of footbridges and other potential obstructions to stream flow.
3. Regularly update flood prone area maps to incorporate the latest data near creeks, shorelines, and other emerging urban flooding areas.
4. Conduct a detailed coastal study of the Duwamish River to better delineate the current and increasing risk of flooding and identify a range of strategies (e.g. hard infrastructure, natural system solutions, etc.) to mitigate the risk. Engage community as partners in determining which strategies to pursue.
5. Assess the benefits of incorporating rolling easements into the next update of the Shoreline Master Plan.
6. Continue to incorporate Green Stormwater Infrastructure (GSI) into development regulations through mechanisms such as The Green Factor program.
7. Evaluate options to encourage or require significant on-site rainwater storage vaults, both to mitigate the impact of heavy winter rainstorms on the City stormwater system and to provide non-potable water for summer irrigation and toilet flushing.

PASSIVE SURVIVABILITY

Passive survivability is the ability for a building to support fundamental functions during an event such as water-, heating-, or power-outage.

For example:

- Windows support habitable spaces with daylighting and operable windows allow ventilation in the event of a power-outage.
- Habitable spaces in underground stories (or portions of stories) have low passive survivability unless lightwells can provide adequate daylight and ventilation.

Landslide Hazard Areas

ACTION

1. Maintain a citywide repository for landslide data, including the locations and dates of slides, and observations about factors that may have contributed to their occurrence.
2. Update the Seattle Public Utilities Landslide Study to reflect current and projected climate conditions.
3. Evaluate mechanisms to support private property owners in making drainage improvements on their property in landslide prone areas, prioritize the needs of communities of color and lower income residents in the analysis.

Energy Management & Cooling

ACTION

1. Evaluate code mechanisms to encourage or require new and renovated buildings to minimize the energy required to operate the building under extreme weather conditions or power loss, particularly using passive building envelope strategies such as high-performance fenestration, insulation, daylighting, natural ventilation and exterior shading.
2. Evaluate current ASHRAE cooling temperature design standards are sufficient to meet projected temperatures which impact cooling peaks and durations.
3. Encourage the use of shade trees to provide additional summer protection for lower floors of building facades and green roofs to reduce heat island effect while providing comfortable exterior environments, and prioritize EEI focus areas.
4. Support the adoption of energy efficiency, insulation, and good windows which reduce energy needs in both winter and summer, and heat pumps to improve energy efficiency and provide cooling capacity during extreme heat events. Prioritize upgrades for EEI populations.
5. Identify opportunities to support the adoption of electric heat pumps in buildings used as community gathering spaces, particularly in EEI focus areas to improve energy efficiency and provide cooling capacity during extreme heat events.

CURRENT CITY INCENTIVES

Seattle City Light (SCL) offers a variety of incentives to help customers save electricity because it is the most cost-effective way to meet our future energy needs. Currently, SCL offers rebates for electrically heated homes. Heat pumps are an energy-efficient primary heat source, regardless of existing heat source, that can heat and cool homes at a fraction of the cost.

Benefits of a Heat Pump:

- Saves energy and reduces monthly expenses
- Easy to install
- Comfortable and quiet
- Built in air conditioner
- No ductwork needed

CITY BUILDINGS

Background/Context:

The City of Seattle owns, maintains, and operates over 650 buildings, totaling approximately 10 million square feet. City-owned buildings range from small storage sheds, to libraries, to the Seattle Municipal Tower, an office building of more than one million square feet. Offices, community facilities (e.g. performance halls and community centers), and operations support buildings make up the majority of the square footage. Libraries, police stations, and fire stations are numerous but each building is relatively small, so they account for a smaller percentage of the total building area.

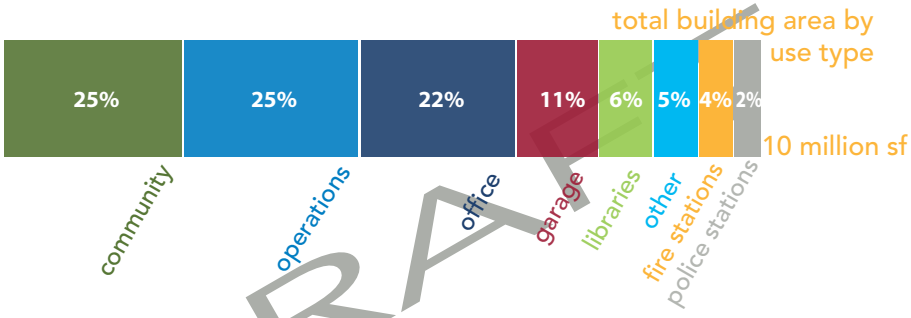


Figure 1. City Building Area by Use Type

This chart was compiled from several sources with the assignment of each building to a single category based on its predominate use. Because many of the City's buildings are multi-use, some use types may be over or under-represented. (Source: City of Seattle; Graphic: GGLO)

City facilities are managed by individual departments. In addition, the Office of Sustainability & Environment oversees Citywide resource conservation management. The following departments all play a direct facilities management role over their own building stock:

- Finance and Administrative Services
- Parks
- Seattle Center
- Seattle Libraries
- Seattle Department of Transportation
- Seattle Public Utilities
- Seattle City Light

CIVIC BUILDINGS

Not all civic and public buildings/ assets are governed by this plan. Some publicly funded buildings, such as schools and public housing, are considered separate agencies

Climate Change Impacts and Implications:

Climate change impacts on operations, maintenance, and design of city-owned buildings include the following:

- Heat events, including extreme heat events and prolonged periods with above average temperatures,
- Precipitation events, including extreme precipitation events and prolonged periods with above average precipitation (related issues: urban flooding, landslides), and
- Sea level rise (related issues: erosion, tidal surge, coastal flooding, salt water exposure)

Table 1 identifies key impacts on City properties and implications for operations and maintenance. While impacts on City-owned properties will vary by facility and location, staff noted that many of the issues identified in Table 1 are problems that staff already contend with to some degree. Changes in the frequency, intensity, and/or duration of these impacts could require more fundamental changes in how these impacts are managed, however.

Asset Class	Climate Impacts and Implications	
	Implications for Assets	Implications for Operations and Maintenance
Buildings and Public Spaces	*Increased potential for:* • Increased need for cooling space/recovery rooms for outdoor workers and those required to wear heavy gear, including fire and police personnel. • Heavier use of city facilities seen as places of refuge during heat events, can lead to exceeding the facility equipment design loads. • More frequent flooding, erosion, and tidal damage to city-owned coastal infrastructure and facilities. • Permanent inundation of low-lying city-owned coastal infrastructure and facilities. • More frequent or extensive urban flooding onto City properties due to stormwater overflow. • Increased temperature-related closures or service reductions at naturally ventilated facilities.	*Increased potential for:* • Increased temperature-related closures or service reductions at naturally ventilated facilities. • Heavier use of mechanical systems for temperature, humidity, and dust control. Increased use raises operating and maintenance costs while also impacting city-wide energy goals. • Increased operating and maintenance costs for facilities seen as places of refuge during heat events. • More frequent maintenance and replacement of assets damaged by erosion, tidal surge, salt water exposure, and flooding. As sea level rises, service reductions and closures become more likely. • Service reductions, temporary closures, and/or damage to facilities as a result of poor drainage and urban flooding.

Table 1. Climate Impacts and Implications: City Buildings

Adaptation Strategies:

Preparing city-owned buildings for the impacts of climate change is important for ensuring the continued reliability of the services provided at those facilities and for protecting the long-term investments made in those assets. The following preparedness strategies are recommended for City facilities and open spaces.

VISION

City-owned buildings are designed, operated, and maintained in ways that reduce the impacts of climate change on City services and residents and ensure that the benefits of adaptation measures and burdens of climate change are equitably shared.

City Buildings and Public Spaces

ACTIONS

1. Evaluate facility design standards against projected future climate conditions including changes to summer temperature, increased precipitation, and sea level rise and identify changes needed to address these changing conditions, including:
   - o Head load transfer: evaluate how design standards could be modified to allow for a larger heat load transfer out of buildings through passive cooling approaches, and when those standards should be applied.
   - o Drainage infrastructure: evaluate design standards for the sizing and slope of lateral drainage systems, onsite detention, and other drainage infrastructure.
   - o Overhangs: evaluate if and how design standards for overhangs, which prevent water damage by reducing the amount of water coming down the face of buildings, should be modified.
2. Include more shade trees in facility design, where possible, to help reduce building temperatures and to provide shade for the public while using facilities and public spaces.
3. Assess the need for passive and active cooling and resilience retrofits by considering the impacts of increasing heat events and higher nighttime temperatures on operations and maintenance budgets, as these circumstances can require HVAC equipment to run 24 hours per day.
4. Evaluate City facilities in areas at risk of landslides and flood including the likelihood and consequences of additional climate- related impacts to these properties and identify additional actions to enhance resilience.

PARKS

Background/Context

The Seattle Department of Parks and Recreation (DPR) develops, maintains, and operates the city's parks and recreation system which includes:

- 6,200-acre park system of 465 parks and extensive natural areas
- Greater than 100,000 trees in developed parks
- Over 500,000 trees in Park's natural areas
- 25 miles of boulevards
- 120 miles of trails
- 26 community centers
- Eight indoor swimming pools and two outdoor (summer) swimming pools
- Four environmental education centers
- Two small craft centers,
- Four golf courses
- An outdoor stadium, and much more

DPR's operations are diverse and their capital asset inventory has grown significantly since 2000 due to several voter-approved funding measures.

Climate Change Impacts and Implications

Through conversations with staff, the most vulnerable assets impacted are:

- Parks property and buildings
- Structures
- Conveyance systems
- Pavement
- Trees and vegetation

Potential climate change impacts on these assets and implications are summarized in Table 2. Broadly speaking, these impacts affect operations and maintenance, asset planning, design and construction, emergency response capabilities, public safety, and the ability to meet service levels at Parks facilities. For example, the increased frequency of 10-year rain events is already requiring additional staff time to inspect and maintain catch basins, many of which need to be upgraded to prevent localized flooding in areas of the park system. Without these upgrades, park assets, which are already suffering from historic deferred maintenance, could continue to decline and require more costly reconstruction.

Asset Class	Climate Impacts and Implications	
	Impacts on Assets	Implications for Operations and Maintenance
Property and Buildings	*Increased potential for:* • Submerged, scoured and/or unusable coastal park properties including Puget Sound Beaches, and buildings • Higher demand for spray parks, wading pools, community centers and other parks assets during extreme events. • Increased impacts for localized flooding of assets.	*Increased potential for:* • Need to armoring, protect and/or replenish Seattle's Puget Sound beaches. • Increased need for short-term (e.g. sand bags) and long-term (e.g. berms, green infrastructure) protection measures for flood-prone assets.
Pavement	*Increased potential for:* • Please see the Transportation section of this report for a complete discussion of the potential asset impacts of climate change on these assets.	*Increased potential for:* • Please see the Transportation section of this report for a complete discussion of the implications for operations and maintenance impacts.
Structures (e.g. bridges, seawalls, retaining walls)	*Increased potential for:* • Landslides in areas with unstable slopes • Erosion of soils, bluffs, and other features adjacent to structures • Weakening of structures in areas affected by seepage, higher groundwater levels • Failure of retaining walls due to higher moisture loads Roadway closures due to structure risk/failure	*Increased potential for:* • More frequent and/or longer duration park/road closures where structures are affected by landslides, erosion, or related impacts • More frequent deployment of emergency response crews to deal with landslides/ erosion issues/wall failure issues • Increased maintenance needs to address erosion and flooding • Public safety issues where slides, erosion, and other structural impacts occur • More frequent replacement of assets due to reduced asset life or added capital costs to retrofit existing assets • Increased need for on-call landslide mitigation, assessment and clean-up services
Conveyance System	*Increased potential for:* • Local flooding due to surcharged outfalls and catch basins • Drainage system backups due to submerged outfalls and/or surcharged pipes	*Increased potential for:* • More frequent and/or longer parking lot, facilities or road closures where drainage impedes usage • More frequent deployment of maintenance crews to deal with drainage issues • Public safety issues where drainage problems exist

Asset Class	Climate Impacts and Implications	
	Impacts on Assets	Implications for Operations and Maintenance
Trees and vegetation	*Increased potential for:* • Tree stress and mortality related to drought, insects, disease, and storms • Downed limbs and trees related to more extreme precipitation and potential shifts in storms	*Increased potential for:* • Longer annual watering seasons and the need to extend the watering period for new trees beyond the current 3-year establishment window • Additional crew time for increased tree watering • Drought-related tree maintenance including fallen branches dead tree removal • Increased tree maintenance to reduce the risk of tree blowdown or limb breakage during storms and droughts • Higher response costs and roadway operations issues associated with damaged signals, wires, and utility poles. • Damage to sidewalks due to root-heaving of drought-stressed trees.

Table 2. Climate Impacts and Implications: Parks & Natural Systems

The climate change vulnerabilities of other assets were also discussed with DPR including electrical assets, exterior mechanical systems and maintenance equipment. However, the degree of climate change risk associated with these assets was determined to be considerably less because of several factors:

- Relatively simple fixes can address potential risks
- Maintenance/replacement cycle can accommodate upgrades to address risks
- Use of standard equipment that is operable over wide temperature ranges
- Current design standards keep equipment out of risk of flooding and sea level rise

Below, we briefly discuss potential impacts and vulnerabilities with these other parks assets.

- Increased summer temperatures and more heat events may impact the usability of synthetic turf fields and play areas due to the heat.
- Increased demand for pools and spray parks during heat events resulting in increased parking demand at parks.

Adaptation Strategies

VISION

The impacts of climate change on the parks system are understood and planned for and the benefits of preparedness measures and burdens of climate change are equitably shared.

Property and Buildings

ACTIONS

1. Conduct an asset management audit of landslide and flood prone assets. Identify the likelihood and consequences of climate related impacts to these properties and prioritizes subsequent actions with the asset management program considering EEI focus areas.
2. Coordinate with other City departments to reduce off-site factors that may exacerbate risks to parks and recreation assets, such as stormwater management facilities in parks properties operated and maintained by Seattle Public Utilities.
3. Strengthen Parks emergency response capabilities through actions, which may include increased stockpiling of supplies, confirming key building systems (e.g. HVAC/passive cooling) are adequate.
4. Begin planning for the increased use of Parks facilities (e.g. pools, beaches, community centers during heat events, particularly in EEI focus areas.
5. Evaluate the potential for increased moisture issues in buildings that house pools.

LANDSLIDES

Landslide prone properties identified by staff include: Golden Gardens, Lake Washington Boulevard, Magnolia Boulevard, Discovery Park, the Burke-Gilman Trail north of 70th, Kinnear Park.

Properties at risk from sea level rise include: Alki, Schmitz Park Seawall, Discovery Park, Lincoln Park Pool and Bathhouses, Waterfront Park, Carkeek Park, Lowman Beach.

Pavement

ACTIONS

1. Integrate SDOT's findings for pavement specifications into DPR standard specifications and details.
1. Increase the use and frequency of preventive maintenance treatments that would address accelerated pavement wearing (e.g., seal coats, crack seals).

PAVEMENT

Other than SDOT, Seattle Department of Parks and Recreation (DPR) is the largest manager of paved assets in the City of Seattle, which means they face many of the same challenges regarding pavement maintenance, repair and replacement. In addition to internal park drives and parking areas, DPR owns and/or manages more than 25 miles of boulevards. These include Magnolia Boulevard, Queen Anne Boulevard, Cheasty Boulevard, Lake Washington Boulevard and others. Many of these roads have associated appurtenances like: bridges, seawalls and retaining walls.

Structures

ACTIONS:

1. Identify locations and vulnerability of structures (e.g. retaining walls, sea walls, staircases, and bridges) that may require retrofit due increases in high intensity rain events and coastal flooding and develop a strategy for mitigation risks, prioritize locations in EEI focus areas.
2. Coordinate with other City agencies to reduce any off-site factors that may exacerbate risks to parks and recreation assets, such as working with other departments to enforce illicit drainage discharges onto Parks lands.
3. Identify increased operation and maintenance costs for bridges due to chance in heat, flooding, and abutment erosion.
4. Work with first-responders to identify key routes for emergency vehicle access that may be compromised by structure failures. For example, limited routes through parks or along water bodies where early notification of closures can reduce impacts to response times.
5. Increase training for staff around erosion, sediment, landslides, risk identification and management, etc.

EMERGENCY RESPONSE

Seattle Department of Parks and Recreation staff and facilities are called upon in a wide range of ways during emergencies. Community centers serve as shelters and food preparation facilities, pools and spray parks as cooling centers, parks as distribution hubs. The active planning of these diverse emergency response needs across the system will help the City in its overall emergency preparedness.

Conveyance Structures

ACTIONS:

1. Audit existing Parks-owned and managed catch basins and outfalls, review capacity of existing standard drainage structures based on increased precipitation projections, and identify the likelihood and consequences of climate related impacts to these properties and develop a prioritized action plan, considering impacts in EEI focus areas.
2. Work with first-responders to identify key routes for emergency vehicle access that may be compromised by flooding from inadequate catch basins or areas without drainage infrastructure.
3. Continue to collaborate with SPU and other city agencies to reduce chronic flooding that reduces the usability and/or safety of parks.

Trees and Vegetation

ACTIONS

1. Continue to research and modify the approved tree list to reduce risks related to heat and increased precipitation, including identifying species that can be used in areas where flooding and/or high groundwater may occur and species appropriate for anticipated temperature changes. Work with nurseries to ensure availability over time.
2. Prioritize tree planting and other natural system strategies to reduce heat islands, mitigate storm surges, buffer pollution sources in communities with demographics which indicate higher levels of pre-existing health conditions and other susceptibility to the impacts of climate change. Consider EEI populations and focus areas in the prioritization process.
3. Due to increased stressors, increase the tree establishment period from 3 years to 4 years.
4. Increase stewardship capacity and protocols to better maintain existing vegetation and restore the urban forest.
5. Evaluate the budget implications of additional watering/establishment care, storm/drought maintenance, and tree removal and replacement.
6. Evaluate options for using non-potable water for watering.
7. Evaluate using technology to inform watering decisions in order to more efficiently use existing water resources. Consider increasing the watering season as summer drought conditions last longer.

DRAINAGE & WATER SUPPLY SYSTEMS

Drainage, Wastewater, and Water Supply Chapter

Seattle Public Utilities (SPU) views climate change as a strategic issue that requires a sustained effort to understand and prepare for the impacts of climate change. This perspective is reinforced by the inclusion of climate adaptation in SPU's Strategic Business Plan, which was adopted in 2014, and by the existence of a group within SPU's Director's Office, the Climate Resiliency Group, that is focused on climate change. The following sections summarize SPU's strategic approach to climate change and specific actions for addressing climate change impacts on the drainage, wastewater, and water supply services provided by SPU.

SPU's Strategic Approach to Climate Change

The following foundational elements are integral to SPU's overall strategic approach to assessing and preparing for climate change across SPU operations and services.

Knowledge Enhancement

Given the emergent and evolving nature of climate impacts research, SPU feels it is critical to view climate change as an opportunity for ongoing learning and knowledge enhancement. We have developed and continue to cultivate relationships with the research community in order to facilitate knowledge transfer and to convey our climate research needs. SPU staff serves on the Stakeholder Advisory Committee of the Climate Impacts Research Consortium, a NOAA funded climate research group for the Pacific Northwest, and routinely collaborates on research projects and/or proposals that provide an opportunity to address knowledge gaps.

Capacity Building

SPU has focused on expanding the nature of our climate work and doing more of it with SPU staff. Building on a series of studies assessing the impacts of climate change on supply, we have been able to build our internal capacity and more clearly define the potential impacts of climate change on our supply and demand. In addition, SPU has recruited and hired staff with specialized skills to support adaptation activities. For example, SPU has an in-house meteorologist who has been instrumental in developing enhanced and customized weather forecasting services and leading our efforts to differentiate that varying sensitivities of our in-city watersheds to precipitation.

Collaborative Partnerships

SPU is a founding and ongoing member of the Water Utility Climate Alliance (WUCA), a group of ten large urban water utilities that collaborate on improving the usefulness of climate science and enhancing decision making in the face of climate uncertainty. WUCA provides SPU with an opportunity to learn from peers who are addressing similar challenges and to jointly fund research to address knowledge gaps. SPU staff also chair the Project Advisory Board of an

EU-funded research project focused on innovation in water management and climate change. These, and other, collaborative activities reinforce our goals for knowledge enhancement and help to keep SPU aware of emergent approaches and practices for preparing for climate change.

Engagement with Federal Initiatives

SPU has been and continues to be active in engaging federal agencies efforts to support climate adaptation at the local level. SPU staff chaired EPA's Climate Ready Water Utility Working Group, served on the National Climate Assessment Development Advisory Committee, contributed to the water resources and adaptation chapters of the 2014 U.S. National Climate Assessment. SPU staff also currently serve on NOAA's Climate Working Group. SPU views this engagement as an opportunity to articulate to federal agencies the needs of SPU and the water sector as well as an opportunity to learn about emerging practices and federal climate-related activities.

VISION

Drainage and water supply systems are planned, designed, and constructed to be resilient to the impacts of climate change

Drainage and Wastewater

Background/Context

SPU provides drainage and wastewater services in the city of Seattle through our Drainage and Wastewater Line of Business (DWWLOB). The DWWLOB owns, operates and maintains a vast array of assets and infrastructure in order to the protect public health, property and the aquatic environment of Seattle. Some of the existing assets under DWWLOB's management or affected by DWWLOB operations include:
In addition there are 43 miles of creeks within the city limits and the DWWLOB owns numerous assets along or near the marine shoreline of Puget Sound.

- 475 miles of separated sanitary sewers
- 474 miles of combined sewers
- 68 pump stations
- 34 miles of wastewater force mains
- 87 city-owned and permitted combined sewer overflow points
- 40 combined sewer overflow detention tanks/pipes
- 483 miles of storm drains / 305 storm drain outfalls
- 33,733 catch basins
- 59 miles of ditches, 46 miles of culverts
- 7 miles of green infrastructure
- 181 flow control facilities, 23 detention/ treatment ponds
- 372 water quality structures

The DWWLOB has four divisions, besides administration: Drainage and Wastewater Planning and Program Management; System Assessment, Operations and Monitoring; Drainage and Wastewater Systems Maintenance; Source Control and Pollution Prevention.

Climate Change Impacts and Implications for Drainage and Wastewater Services

The DWWLOB's assets and services are exposed and sensitive to two primary climate factors: potential changes in extreme precipitation and sea level rise. Given that existing Drainage and Wastewater (DWW) assets and infrastructure have generally been designed based on historic precipitation patterns and a targeted level of service , a departure from those patterns in the future towards shorter duration/more intense precipitation events could make it more difficult to meet service level standards, recognizing that other factors (e.g., increases in imperviousness, asset maintenance, etc.) can also impact current service levels. In effect, this can be categorized as an existing system capacity issue that has potential implications for the DWWLOB's services and assets as well for other interconnected systems within the city, such as roadways.

Projected changes in sea level rise also have potential implications for the DWWLOB's services and assets through the potential inundation of assets and higher water levels impeding the ability of stormwater to be conveyed.

A secondary climate factor is the potential for the timing of windstorms to occur earlier in the fall when trees still have a significant portion of their leaves. If coupled with rainfall, such an occurrence can exacerbate capacity issues in the DWWLOB pipe network because of the downed leaves clogging catch basins and inlets.

Drainage

ACTION

Through its Strategic Business Plan, SPU dedicated funding to develop a DWWLOB adaptation study and strategy. The work on the strategy will be initiated in 2016 and is currently scheduled to be completed in 2019. The scope of the strategy is being determined now but will likely focus on identifying and evaluating a portfolio of innovative approaches to managing stormwater in an urban context in a changing climate. It will also build on the existing work done to date to enhance SPU's

understanding of the potential impacts of climate change and to strengthen our ability to forecast storm events. Some of these activities, which span operations to long term planning, include:

1. Through its Strategic Business Plan, SPU dedicated funding to develop a DWWLOB adaptation study and strategy. The work on the strategy is being initiated in 2016 and is scheduled to be completed in 2019. The full scope of the strategy is being

determined now but will include work to identify and evaluate a portfolio of innovative approaches to managing urban stormwater in a changing climate. It will build on the existing work to date to enhance SPU's understanding of the potential impacts of climate change and to strengthen our ability to forecast storm events. Some of these activities, which span operations to long term planning, include:

2. Precipitation Threshold Analysis: The DWWLOB is currently conducting a threshold analysis of the sewer network to determine the sensitivity of the network to different types of storm events.
3. Climate Resiliency Study: SPU is completing an analysis that examines what affects the combined effects of sea level rise and extreme rainfall events would have on the drainage network in several tidally influenced basins
4. Observed and Climate Perturbed IDFs: SPU is currently updating the Intensity, Duration, Frequency (IDF) curves used by stormwater infrastructure designers to inform the sizing of new infrastructure. The first phase will update the IDFs through 2015 and provide spatially disaggregated IDFs throughout the city. The second phase will attempt to develop "climate perturbed" IDFs that can credibly enable the inclusion of a climate signal in the design of stormwater infrastructure. To date, SPU has reflected a climate signal through the use of a precipitation scaling factor through work to reduce combined sewer overflows.
5. Climate Policies: The DWWLOB intends to develop a suite of climate policies over the course of the next two years. While the scope and focus of the policy development is under discussion, it is anticipated to include guidance on how some of the previously described analysis should be utilized and incorporated into DWWLOB decision-making .
6. Stage Gates: SPU's Stage Gates is a governance system that helps SPU make informed decisions about the planning, selection and delivery of capital projects and programs. SPU has integrated preliminary climate considerations into the Stage Gates process and in 2016 will be building on that effort to date to more fully incorporate climate considerations into that system.
7. Green Stormwater Infrastructure (GSI) Capital Program: Given Seattle's goal of achieving 700 million gallons of stormwater managed annually with GSI per year by 2025, SPU is delivering on its commitment to evaluate GSI for all large-scale capital investments, including investments to enhance the climate resiliency of the DWW system. An example of this is the NDS Partnering Program overlay with the Localized Flooding Program to identify investments that would deliver both water quality improvements and flood reduction. As discussed above, GSI projects are currently designed to include a scaling factor to account for climate uncertainties.

Water Supply

Background/Context

Seattle Public Utilities owns, operates and manages the city's drinking water supply system. Key features of SPU's drinking water system are:

- SPU retails and wholesales high quality drinking water to roughly 1.3 million people in Seattle and other jurisdictions in King County
- The average daily demand in 2015 was 126 million gallons per day.
- There are two primary sources of supply: the Cedar River and South Fork Tolt River; SPU also owns three groundwater wells that are used infrequently for peak usage and/or emergencies
- SPU owns 99.8% of the land in the Cedar River Watershed above the Landsburg diversion point and 68.8% of the land above the South Fork Tolt Dam
- Water quality treatment for both the Cedar and South Fork Tolt includes screening, ozonation, chlorination, fluoridation and corrosion control. In addition, there is filtration on the Tolt and ultraviolet light disinfection at the Cedar treatment facility.
- SPU owns and maintains 1,873 miles of pipeline
- SPU has a Habitat Conservation Plan for its operations associated with the Cedar River. The HCP focused on the restoration of the terrestrial and aquatic ecosystems of the Cedar River Watershed.
- In addition to drinking water services, SPU provides instream flows for aquatic habitat and flood management.

Climate Change Impacts and Implications section:

Climate variability and climate change are factors that SPU considers in ensuring that current and future water demands for people and fish are met. 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 can alter weather patterns and affect air temperatures, humidity, evaporation, cloud cover, rainfall, snowfall, snowpack, and runoff, in terms of averages, extremes, timing and distribution. SPU has researched the timing and magnitude of these changes and their effects on SPU's water supply through two climate impacts studies. The results of those studies have been included in SPU's most recent state-mandated water system plans (the 2007 and 2013 Plans). Both studies projected a decrease in supply over time due to climate change, with the second study projecting an increase in demand as well (the first study did not examine demand). With the second study, SPU identified and evaluated adaptation options which SPU could deploy to mitigate the impacts on supply. As a result of the second study, SPU

determined that if climate projections were factored into supply and demand, it would have sufficient supply to demand until the 2060's. SPU is currently updating this analysis with a third climate impacts study (described below).

Water Supply

ACTION

SPU has had a sustained and enduring focus on assessing how climate change may affect Seattle's drinking water supply dating back to the late 1990's. SPU is currently engaged in a third climate change study using customized local climate projections obtained through a research agreement with Oregon State University. The current study, which is referred to as Piloting Utility Modeling Applications (PUMA), utilizes 40 climate scenarios to assess the potential impacts of climate change on SPU's water supply. Additional research conducted via the PUMA project has examined how climate change may" affect fire intensity in the central Cascades, alter the timing of fall rains, and change the frequency that existing thresholds (e.g., number of days with a max temp below freezing) are exceeded. The results of SPU's current climate change study will be included in SPU's 2019 Water System Plan.

SPU's ongoing commitment to assess and understand the impacts of climate change is reflected in the inclusion of an action plan focused on climate resiliency in SPU's Strategic Business Plan. In addition to assessing the potential impacts of climate change on water supply under the 40 scenarios, SPU's climate resiliency action plan includes:

1. Identifying and assessing the utility of adaptation options in offsetting climate impacts on supply and demand (to be completed in 2017). The climate impacts and adaptation analysis will be included in SPU's next update of its water system plan, which is due in 2019.
2. Assessing the vulnerability of our forested watersheds to fire and developing a strategy to address that vulnerability.
3. In partnership with the Cedar River Habitat Conservation Plan (HCP) Oversight Committee, exploring how to extend our climate analysis to assess potential climate impacts on fisheries of concern in the Cedar River.

ELECTRICITY SYSTEM

Background/Context

Seattle City Light is the 10th largest public electric utility in terms of customers served, providing power to more than 360,000 residential customers and 40,000 non-residential customers in the city of Seattle and communities to the north and south. Seattle City Light infrastructure includes dams, power lines, substations, and other equipment for hydroelectric power generation, transmission, and distribution. This includes:

- Five hydroelectric projects:
  Boundary (1,078 MW), Pend Oreille River;
  Skagit (848 MW), Skagit River;
  Cedar Falls (30.0 MW), Cedar River;
  South Fork Tolt (16.8 MW), South Fork Tolt River;
  Newhalem (2.0 MW), Newhalem Creek
- 637 miles of overhead transmission lines
- 23 miles of underground transmission lines
- Four transmission substations
- Steel (primarily), wood, and concrete transmission poles
- 15 distribution substations
- 2,337 distribution circuit miles (1,763 overhead and 574 underground circuit miles)
- 220 network system distribution circuit miles, all underground
- Transformers (pole mounted, pad mounted, and submersible)
- Transmission towers (primarily steel and some wood)
- Distribution poles (primarily wood and some steel)

In 2015, Seattle City Light completed a Climate Change Vulnerability Assessment and Adaptation Plan evaluating the potential impacts of climate change on Seattle City Light's shoreline infrastructure, electricity demand, transmission and distribution systems, hydroelectric projects, and fish habitat restoration activities.[1] The plan identified potential actions that the utility could take to prepare for climate change. Key findings and priority actions from that report are summarized here.

1 Seattle City Light Climate Change Vulnerability Assessment and Adaptation Plan. Available at http://www.seattle.gov/light/enviro/climatechg.htm

Climate Change Impacts and Implications

Seattle City Light's plan identified eight changes in climate and related changes in extreme weather, natural hazards, and streamflow that could affect Seattle City Light's operations and infrastructure:


Sea level rise and more frequent coastal flooding


Increasing risk of landslides and erosion


Warmer temperatures and more frequent heat waves


Reduced snowpack and changes in streamflow timing


Changes in extreme weather patterns


Higher peak streamflows and flood risk (fall/winter)


Increasing risk of wildfires


Lower streamflows (spring/summer)

Potential impacts and implications for operations, infrastructure, and revenue are summarized in Table 1.

In addition to these direct effects of climate change, several indirect effects of climate change on energy policies and markets could also affect Seattle City Light. Multiple policies are currently in development at the state and federal level to reduce emissions of greenhouse gases from the energy sector. Concern about climate change and efforts to reduce emissions of greenhouse gases are supporting rapid development of non-hydro renewable energy sources and a market for these resources, including small-scale distributed wind and solar generation. Electrification of the transportation sector to reduce emissions is also likely to increase demand for electricity in the near-term. In contrast, changes in building codes to increase energy efficiency are expected to reduce electricity demand, despite rapid development in Seattle. Furthermore, Seattle City Light purchases and sells power on the wholesale market, so regional changes in electricity supply and demand caused by both direct and indirect effects of climate change throughout the western region could have implications for operations and revenue of the utility.

SCL Asset Class or Function	Climate Impacts and Implications	
	Impacts on the Asset Class or Function	Implications for Operations and Maintenance
Shoreline Infrastructure	*Increased potential for:* • More frequent coastal flooding and inundation of shoreline properties	*Increased potential for:* • Additional repair and maintenance costs at affected properties • Mobilization of hazardous materials from contaminated sites exposed to sea level rise and more frequent coastal flooding • Temporary loss of full access or function at affected facilities
Electricity Demand	*Increased potential for:* • Higher electricity demand for cooling in summer, particularly in the commercial sector for which air conditioning use is higher than the residential sector • Lower electricity demand for heating in winter	*Increased potential for:* • Summer electricity peaks to near winter peaks in areas with high commercial loads • Changes in seasonal retail sales and revenue (more in summer, less in winter)
Transmission and Distribution	*Increased potential for:* • Salt water corrosion and flooding of shoreline facilities and equipment • Urban flooding near transmission and distribution equipment • Warmer temperatures to reduce life expectancies of insulated transmission and distribution equipment, such as transformers • Wildland fires and landslides to damage transmission lines and access roads • River flooding and erosion near transmission towers and access roads	*Increased potential for:* • Higher maintenance, repair, and replacement costs for equipment and infrastructure • Reduced safe access to damaged equipment and slower repair and outage restoration times following storms • Temporary interruptions of transmission due to damage or required outages • Lost revenue when interruptions to transmission reduce wholesale power sales, require wholesale power purchases to meet demand, or both

SCL Asset Class or Function	Climate Impacts and Implications	
	Impacts on the Asset Class or Function	Implications for Operations and Maintenance
Hydroelectric Projects	*Increased potential for:* • Changes in the seasonality of streamflow • Insufficient water supply in summer for reservoir recreation, instream flows for fish protection, and hydropower generation • More frequent spilling at projects in fall and winter for flood control • Wildland fire damage of hydroelectric facilities and historical buildings	*Increased potential for:* • Changes in operations to meet objectives for flood control, fish protection, reservoir recreation, and hydropower generation • Reduced hydropower generation in spring and summer • Reduced fall and winter revenue associated with more frequent spilling • Fish mortality and damage to fish habitat with more frequent spilling • Temporary interruptions of generation • Lost revenue if generation interruptions lead to lost wholesale power sales, higher wholesale power purchases to meet demand, or both • Wildland fire-related safety concerns for employees and residents at the hydroelectric facilities • Higher maintenance, repair, and replacement costs for equipment and infrastructure
Fish Habitat Restoration & Protection	*Increased potential for:* • Lower summer streamflow and warmer stream temperatures to reduce fish habitat quantity and quality • Higher fall/winter streamflows to cause fish mortality and scour eggs • Higher fall/winter streamflows to damaged habitat and reduce habitat quantity	*Increased potential for:* • Challenges to meeting objectives for fish habitat restoration projects because of damage to restoration projects or reduced habitat quality • Lack of anticipated habitat protection through land acquisitions because of reduced habitat quality and declining fish populations

Table 1. Climate Impacts and Implications: Electricity System

Italics indicate the primary climate driver(s) causing the impact.

Adaptation Strategies

Seattle City Light's Climate Change Vulnerability Assessment and Adaptation Plan identifies potential adaptation actions that the utility can consider to reduce the impacts of climate change and increase resilience. The plan includes near-term actions that can be accomplished with existing capacity and resources and long-term actions that may require additional resources, capacity, or information to implement. The actions listed here are a subset of the near-term actions that the utility anticipates being able to accomplish in the 5-year time frame of the city's Climate Impacts Preparedness Plan. These actions include work already underway as part of Seattle City Light's Climate Initiative (2013 Strategic Plan), as well as new actions anticipated as part of this initiative in the next five years.

VISION

Seattle City Light is able to continue producing and delivering environmentally responsible, safe, low-cost, and reliable power as the climate changes. The utility will have a strong understanding of the potential impacts of climate changes on assets, hydropower generation, transmission, distribution, and environmental functions of the utility and can take proactive measures to reduce these climate risks.

Shoreline Infrastructure

ACTIONS

1. Make spatial information on projected sea level rise and more frequent coastal flooding readily available to all divisions of Seattle City Light for use in planning for facilities and equipment located near Puget Sound.
2. Consider the potential effects of sea level rise and more frequent coastal flooding on facilities through the facilities master planning process for the South Service Center.
3. Develop a process through which new large projects and facilities can be evaluated for potential impacts of sea level rise and coastal flooding within the life expectancy of the project or facility.

Electricity Demand

ACTIONS

1. Update and expand Seattle City Light's assessment of the long-term effects of warmer temperatures (winter and summer) on load by including climate change scenarios in load forecasting and the Integrated Resource Plan. Develop a process to evaluate potential effects of these changes in demand on revenue.
2. Research potential long-term effects of warmer summer temperatures and extreme high temperatures on summer load peaks and changes in residential air conditioning use in the service area.

Transmission and Distribution

ACTIONS

1. Increase capacity of Seattle City Light employees to prepare for and respond to wildland fire risks through additional education, wildland fire training, and mutual aid agreements.
2. Continue to participate in the Firewise program to increase knowledge and capacity to prepare for wildland fires at the Skagit Hydroelectric Project.

3. Continue to pursue actions and grant opportunities to upgrade infrastructure with fire-resistant materials and enhance fire protection and response equipment and capability at the Skagit Hydroelectric Project and the towns of Newhalem and Diablo.
4. Collaborate with resource management agencies and the Skagit Conservation District to research the most effective and environmentally responsible ways to implement vegetation treatments to reduce wildland fire risk.
5. Collaborate with adjacent land owners to reduce flammable vegetation and wildland fire risk along transmission lines and near critical infrastructure at the hydroelectric projects, including efforts to increase defensible space around facilities and buildings in Diablo and Newhalem.
6. Collaborate with state resource management agencies and academic institutions to map landslide risk along transmission line rights-of-way and critical access roads, including research on the effects of heavier precipitation on existing landslide risk.
7. Evaluate increasing erosion and flood risk to transmission towers along the Skagit transmission line, with an emphasis on understanding the additional risk posed by higher peak flows.

Hydroelectric Project Operations

ACTIONS

1. Update Seattle City Light's assessment of how operations of the Skagit Hydroelectric Project may be affected by changes in streamflow using the latest research funded by the utility's Climate Initiative. Projected impacts on hydropower generation (and other objectives of the project) will be used to inform Integrated Resource Plans and potential actions to address climate change in the FERC relicensing process.
2. Update Seattle City Light's assessment of how operations at the Boundary Hydroelectric Project could be affected by changes in streamflow using the latest research from the Joint River Management Operating Committee II (RMJOC II). In 2016, the RMJOC II will complete a study on the effects of climate change on the Columbia River Basin hydroelectric system. This research can be used to evaluate effects on the Boundary Hydroelectric Project and BPA hydropower purchases.
3. Collaborate with Seattle Public Utilities to assess the effects of changes in streamflow on operations of the South Fork Tolt and Cedar Falls Hydroelectric Projects. Consider this information in long-term planning for the Cedar Falls Hydroelectric Project.

Fish Habitat Restoration & Protection

ACTIONS

1. Consider increases in peak streamflow (fall/winter), lower streamflow (spring/summer), and warmer stream temperatures in prioritizing land acquisitions for fish habitat mitigation lands.
2. Consider increases in peak streamflow (fall/winter), lower streamflow (spring/summer), and warmer stream temperatures in objectives and design of restoration projects on fish habitat mitigation lands.
3. Collaborate with federal, state, and tribal resource management agencies to directly address climate change impacts on fish populations and habitat in recovery planning for fish species listed under the Endangered Species Act.

COMMUNITY PREPAREDNESS

Background/Context

Scientists anticipate that the most significant climatic changes in the Pacific Northwest will be to temperature, precipitation, and sea level. Specifically, residents of Seattle will experience hotter, drier weather with more extreme high-heat days in the summer and warmer, wetter weather in the winter. These seasonal changes have the potential to impact human systems in many ways:

Hotter, drier summers with more extreme heat days	Warmer, wetter winters
Increased risk of heat-related illness (heat stroke, heat exhaustion, etc.) and exacerbation of existing medical conditions	Increased demands on emergency response services because of more frequent and intense flooding events
Increased demand for cooling centers, especially for frontline communities	Changes to mosquito populations, requiring additional disease vector control efforts
Earlier and extended allergy seasons affecting those with asthma and respiratory disease	Increased mold spore growth, triggering asthma and other chronic health conditions
Higher electricity bills due to increased need for air conditioning	Less energy needed to heat buildings during winter months
Higher food prices as a result of droughts.	Higher food prices as a result of increased flooding

Emergency Planning

Projected climate impacts on temperature, flooding, storms, and disease have the potential to exacerbate disaster impacts on our community. The city's Office of Emergency Management incorporates climate change impacts into emergency preparedness and response plans. Specifically, the Seattle Hazard Identification and Vulnerability Analysis (SHIVA) identifies 18 major hazards that can produce disaster, including those directly related to climate change: extreme heat events, flooding, winter storms, wind storms and landslides. The Office's focus coordinating the community's effort to reduce impacts of the most complex and extreme presentations of climate change related hazards. The city's emergency plans are 'all-hazards' meaning that they focus on disaster consequences (e.g., displacement of people from their homes) rather than cause (e.g., flooding). Being all-hazards means that the city can have one plan to address many hazards. Individual departments take on slower onset challenges like the expected extension of the allergy season. The Office of Emergency Management should retain climate change as an element that is explicitly addressed in its planning.

ACTIONS

1. Continue to factor climate change projections into emergency preparedness and recovery planning, including future updates to the Seattle Hazard Identification and Vulnerability Analysis, the Seattle Comprehensive Emergency Management Plan and the Disaster Recovery Framework.

2. Strengthen capabilities of individuals, households, neighborhoods, businesses and organizations that assist in disaster response to prepare for potential climate change impacts, including disproportionate impacts on frontline communities through participatory planning, training, educational materials, and volunteer development.
3. Recognize that disaster impacts will increase as a result of climate change, especially in frontline communities, and incorporate the changes in emergency plans and in programs designed to increase community resilience.
4. Develop and distribute culturally appropriate and accessible materials about the impacts of climate change and how individuals can prepare.
5. Evaluate the potential for solar/storage projects to support critical facility operation during extreme events when the grid power supply is not available.
6. Identify between 200 and 250 locations throughout the City to serve as hubs, or emergency rally points, so residents are always within a ½ mile of a hub.

Extreme Heat Event Response

More frequent and longer heat waves will cause more heat related illnesses, decrease quality of life by increasing strain on Seattle's infrastructure and place an economic burden on lower income households through increase energy costs. Extreme heat events are among the most deadly disasters. Hundreds of people died during a 1995 Chicago heat wave. Social conditions have a big effect on heat related mortality. In the Chicago case, fear of crime caused many elderly to keep their doors and windows closed exacerbating heat. The Seattle community will have to mitigate not only direct heat risk, but also indirect risks that can dramatically boost extreme heat risks.

ACTIONS

1. Evaluate the temperature thresholds that trigger the City's heat response to ensure they adequately account for weather conditions, factors impacting indoor building temperatures (e.g. materials, orientation, etc.), and frontline communities.
2. Facilitate access to safe and cool spaces during extreme heat events prioritizing frontline communities (the elderly, people with disabilities, people of color and lower income residents).
3. Conduct outreach to prevent animals from being left in cars unattended on days with high temperatures.
4. Provide training for public safety staff in recognizing and responding to the physical and behavioral signs of heat-related illness.
5. Support installation of heat pumps to provide cooling where most needed.

Food Systems

The crops, livestock, and fisheries that supply our local food, as well as the global food distribution system, could be significantly affected by changes in temperature and the frequency and intensity of extreme weather including floods and droughts. While the 2012 drought in the United States and Europe was just one year, it provides us with a glimpse of the impacts climate change can have on food supplies. Impacts on food supply can affect global food prices, limiting access to affordable healthy food, particularly for lower income residents.

ACTIONS

1. Strengthen the local and regional food system by implementing the Seattle Food Action Plan and consider the impacts of climate change on access to healthy, affordable food in future Plan updates.
2. Expand community gardening and urban agriculture opportunities at P-patches, schools, and available vacant land.
3. Continue efforts to preserve farmland near the city through land use and Transfer of Development Rights policies.
4. Provide support for safety-net programs including food banks, meal programs, summer lunch, and Fresh Bucks, which can provide needed access to healthy food for low-income residents in the case of rising food prices.

WHAT YOU CAN DO

PREPARING FOR CLIMATE CHANGE

While we must make concerted efforts to reduce greenhouse gas emissions, historic emissions have and will continue to impact global climate. Additionally, the slow progress in significantly reducing future emissions means that additional climate change is guaranteed, exacerbating the impacts communities are already experiencing. Climate scientists anticipate the most significant climatic changes in the Pacific Northwest will be to temperature, precipitation, and sea level.

In addition to what City government can do to improve the resilience of our built and natural environment to these changes, there are many actions you can take at work and at home and with your neighbors to increase resilience at the neighborhood and household level. The following pages provide an overview of projected climate impacts, how these changes will affect us, and actions we can all take with links to programs which provide helpful information and resources.

HIGHER TEMPERATURES

What's changing?[1]

	NEAR TERM (By the 2050s)	LONG TERM (By the 2080s)
Higher average annual temperatures	Seattle's average annual temperature is projected to increase between 2.9 to 7.1 degrees Fahrenheit.	Seattle's average annual temperature is projected to increase between 2.3 to 17 degrees Fahrenheit.
Higher summer temperatures	Average summer temperatures are projected to increase as much as 9.7 degrees Fahrenheit.	Average summer temperatures are projected to increase as much as 15 degrees Fahrenheit.
More extreme heat events (days over 92 degrees Fahrenheit)	The frequency and duration of extreme heat events is projected to increase.	The frequency and duration of extreme heat events is projected to increase further.

Table 1. Projected Effects of Higher Temperature For more information, see the Seattle Climate Action Plan, http://www.seattle.gov/Documents/Departments/OSE/2013_CAP_20130612.pdf

What challenges do higher temperatures pose?[2]

- More frequent and longer heat waves will put Seattle residents at risk for illnesses like heat stroke and heat exhaustion.
- Warmer weather may increase the amount of smog that forms in some areas. Smog can irritate your lungs, trigger asthma attacks, and lead to serious heart and lung diseases.
- Higher temperatures can allow mosquitoes and other pests to spread to areas that were once too cold for them and to transmit diseases for a longer part of the year.
- Higher temperatures may be exacerbated in Seattle (relative to more rural areas) because of the urban heat island effect. Impervious and artificial surfaces like buildings and roads retain more of the sun's energy, raising ground and nearby air temperatures. The high energy usage in cities, from heating and ventilation systems to automobile traffic, also produces waste heat.

Who is most at risk from higher temperatures?[3]

- Heat waves are especially hard on the elderly, people with low incomes, and those already suffering from chronic illnesses.
- People who live alone, who do not feel safe enough to open windows for cooling, or lack passive and/or active cooling (such as air conditioning) are at even greater risk.[4]
- Pets are especially vulnerable in high heat.

North Acres Spray Park, Tacoma, Washington (Source: Seattle Parks and Recreation)

What can you do to prepare?[5]

- Increase shade around your home: Planting trees and other vegetation lowers surface and air temperatures by providing shade and cooling through evapotranspiration. You can request up to four free trees to plant around your house through Seattle's "Trees for Neighborhood" program
- Install green roofs: Green roofs provide shade and remove heat from the air through evapotranspiration, reducing temperatures of the roof surface and the surrounding air. Green roofs absorb heat and act as insulators.
- Check on friends, family, and neighbors: Checking on your friends, family, and neighbors during hot days and making sure they have access to a cool or air conditioned place or cooling centers helps prevent heat-related illnesses and death.
- Take advantage of public cooling centers: The City of Seattle opens up libraries, community centers, and other cool or air-conditioned public spaces for residents to stay cool during extreme heat events. Public pools, water parks, and beaches also offer opportunities to cool off in hot weather. Be sure to know when sites close to you are open.
- Know the signs of heat stress: The risk of diseases like heat stroke and heat exhaustion becomes especially pronounced during heat waves. If you, or someone you know, experiences any of the symptoms (cool, moist skin with goose bumps when in the heat; heavy sweating; faintness or dizziness; fatigue; a weak, rapid pulse; low blood pressure upon standing; muscle cramps; nausea; or headaches), stop all activity and move to a cooler place to rest. Other techniques like taking a cool shower or draping a cold, wet towel around your neck can also help. In the case of more serious symptoms like chills, hallucinations, or slurred speech, call 9-1-1 immediately.

- Drink plenty of water to stay hydrated: Have a beverage with you at all times on hot days, and sip or drink frequently. Don't wait until you're thirsty to drink. Avoid drinks with caffeine, alcohol and large amounts of sugar because they can actually de-hydrate your body.
- Protect your pets: Never leave animals chained or penned up directly in sunlight. Provide a shady area for retreat, a cool surface to lie on, and cold water to drink. If you leave animals indoors, open screened windows, keep a fan running, provide plenty of water, and if possible, leave them in a cool location. Never leave dogs or cats unattended in a closed, locked car—not only is it dangerous, it is also illegal under Washington State law!

Estimated Vehicle Interior Air Temperature v. Elapsed Time

Elapsed time	Outside Air Temperature (F)					
	70	75	80	85	90	95
10 minutes	89	94	99	104	109	114
20 minutes	99	104	109	114	119	124
30 minutes	104	109	114	119	124	129
40 minutes	108	113	118	123	128	133
50 minutes	111	116	121	126	131	136
60 minutes	113	118	123	128	133	138
> 1 hour	115	120	125	130	135	140

Figure 1. Estimated Vehicle Interior Air Temperature v. Elapsed Time[6]
(Source: Jan Null, CCM; Department of Geosciences, San Francisco State University)

WETTER WINTERS

What's changing?[7]

	NEAR TERM (By 2050)	LONG TERM (By 2100)
More precipitation annually	Average annual precipitation is expected to increase 4-5%	Average annual precipitation is expected to increase 6-7%
More rain, less snow at mid- and low-elevations	More precipitation is expected to fall as rain (rather than snow) in local mountain ranges, leading to higher stream flows in winter and early spring	More precipitation is expected to fall as rain (rather than snow) in local mountain ranges, leading to higher stream flows in winter and early spring
More extreme rainfall events	The frequency of extreme rainfall events is projected to increase.	The frequency of extreme rainfall events is projected to increase further

Table 2. Projected Effects of Increased Winter Precipitation For more information, see the Seattle Climate Action Plan, http://www.seattle.gov/Documents/Departments/OSE/2013_CAP_20130612.pdf

What challenges do wetter winters pose?[8,9,10]

- Stronger and more frequent rainstorms can cause flooding and other damage to homes, streets, power lines, and other parts of Seattle's built environment.
- Heavy rains can overwhelm Seattle's storm water infrastructure, backing up sewers and leading to an influx of polluted run-off entering local streams, Lake Washington, Lake Union, and ultimately Puget Sound.
- In big storms, stormwater can rapidly erode sediment from the banks of our streams and waterways.
- More rain and less snow will limit or even eliminate opportunities for snow sports at lower elevations in the Cascades and Olympics.[11]
- Stronger stream flows in winter and early spring may reduce egg-to-fry survival rates of salmon in local watersheds.[12]

(Source: Natalie Jamerson)

Who is most at risk from wetter winters?

- People living near rivers and streams or in coastal areas.
- People living in areas with poor drainage.
- People who earn substantial portions of their livelihoods through the winter tourism industry.
- Those who rely on robust salmon populations (such as the fishing industry and ecosystems) due to salmon eggs and fry impacts in local streams.

What can you do to prepare?[13]


(Source: City of Seattle)

- Keep storm drains clear: Identify nearby storm drains and help keep them clear of leaves and other debris that may clog flows and cause a backup during heavy rainfall.
- Install a rain garden in your yard or planting strip: Rain gardens (or "bioretention cells") are shallow depressions that can hold and infiltrate runoff from roofs and driveways. By slowing and filtering roof or driveway runoff, rain gardens can help protect our streams and reduce sewer overflows and flooding. Seattle Public Utilities' RainWise program offers a variety of resources – including rebates – to help residents install rain gardens.[14]
- Install a rain barrel or cistern: Rain barrels and cisterns can help reduce the peak storm runoff that damages our streams and causes sewer overflows by diverting and storing the rain water that falls on your roof. Seattle Public Utilities' RainWise program offers a variety of resources – including rebates – to help residents install rain barrels and cisterns. Typical rain barrels hold 50 to 80 gallons of water and can be installed relatively easily and cheaply, while cisterns can hold thousands of gallons but are more expensive to install.[15,16]
- Reduce impervious surfaces around your home: Conventional pavement, roofs, and other impervious surfaces speed up rainfall and funnel it to storm drains, contributing to sewer overflows, local flooding, or stream erosion during big storms. You can help reduce these impacts by reducing the amount of paved area around your home, installing green roofs, and by choosing permeable paving options that let the rain soak through into the soil for driveways, walks, and patios.
- Disconnect your downspouts: Some houses in Seattle have their roof gutters and downspouts connected to the sewer system. During heavy rains, water that falls on rooftops

joins with wastewater from our bathrooms and kitchens and can overwhelm the system, leading to combined sewer overflow into Puget Sound. By disconnecting your downspout from the sewer system, you can redirect roof runoff into a rain barrel of a rain garden and decrease the risk of a sewer overflow.

- Know your risk: Check out the Department of Planning and Development Flood Prone Areas map on the City website. You can enter the address or neighborhood where you live or work to see whether or not you are located in a flood prone area (be sure to click to activate the appropriate map layers).
- Prepare for flooding: If you live somewhere with poor drainage or otherwise prone to flooding consider purchasing flood insurance. If a flood warning is issued, move valuable objects to upper floors and place sandbags to divert water away from your home in accordance with local laws. Seattle Public Utilities provides up to 25 free sandbags per household.[17]

DRIER SUMMERS

What's changing?[18]

	NEAR TERM (By the 2040s)	LONG TERM (By the 2080s)
Reduced snowpack in the mountains	Average spring snowpack in the mountains is projected to be reduced by - about 25%, on average.	Average spring snowpack in the mountains is projected to be reduced by about 50%, on average.
Reduced stream flows	Stream flows are likely to be lower in late spring and summer, especially in rivers fed by snow melt.	The likelihood of reduced stream flows in late spring and summer will continue.

Table 3. Projected Effects of Decreased Summer Precipitation

For more information, see the Seattle Climate Action Plan

What challenges do drier summers pose?[19]

- Reduced snowpack in the mountains may strain water supplies during dry summer months.
- Low river flows may reduce power generating capacity of Seattle City Light's hydroelectric plants, requiring more wholesale purchases to meet summer demand.
- Low flows and higher water temperatures may reduce the reproductive success for many salmon populations in local watersheds.[19]
- Extended periods without rainfall can stress trees and other vegetation, making them more susceptible to disease and subsequent storms.

(Source: KUOW 94.9 Public Radio -Flickr Creative Commons: https://flic.kr/p/5bj6Up)

Who is most at risk in dealing with these challenges?

- Everyone! We all rely on Seattle City Light for electricity and Seattle Public Utilities for water.
- Salmon returning to spawn local streams.
- Trees and other plants that are not drought tolerant.

What can you do to prepare?

- Use water- and energy-efficient appliances and equipment: Not only do high-efficiency appliances help to reduce water use during drought, they also conserve energy. Seattle City Light offers rebates on most ENERGY STAR-certified appliances, and will even pay you to recycle your old refrigerator.
- Conserve water around the house: Making small changes to your everyday behavior can yield big water savings, which will help our region's water and energy supply be more resilient to climate change. The Washington State Department of Ecology and Seattle Public Utilities' Saving Water Partnership offer a variety of resources to help you reduce water use in your bathroom, kitchen, laundry, and more.
- Install a rain barrel or cistern: Water catchment systems like rain barrels can trap and store water that falls on your roof in the spring to irrigate your lawn or garden in summer. Seattle Public Utilities' RainWise program offers a variety of resources – including rebates – to help residents install rain barrels and cisterns.[20,21]


(Source: City of Seattle)

- Replace your lawn with drought-tolerant vegetation: Nationwide, lawns and gardens account for nearly one-third of all residential water use, totaling nearly 9 billion gallons per day. Alternatively, many species of plants can thrive solely on our limited summer rainfall, saving Seattle residents time and money on watering. Seattle Public Utilities offers resources on choosing the right plants to fit your yard. Alternatively, consider substantially limiting how frequently you water your lawn and allow your lawn to go dormant during the summer.[22]

RISING SEA LEVELS

What's changing?[23]

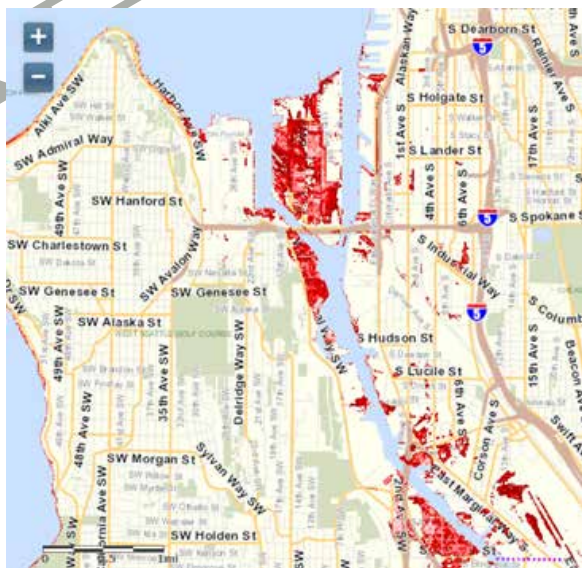
	NEAR TERM (By the 2050s)	LONG TERM (By 2100)
Higher base sea levels	Base sea level around Seattle is projected to rise by up to 9 inches by the 2030s and up to 19 inches by the 2050s.	Base sea level around Seattle is projected to rise by up to 56 inches by 2100.
Higher storm surges and high tides	Storm surges and high tides will continue to periodically increase sea level. The highest observed water level was 38 inches above an "everyday" high tide, meaning a storm surge in the 2050s could potentially be 57 inches higher than current high tide levels.	Storm surges and high tides will continue to periodically increase sea level. Given base sea level rise, a storm surge in 2100 could potentially be 94 inches higher than current high tide levels.

Table 4. Projected Effects of Rising Sea Levels

For more information, see the Seattle Climate Action Plan, and the Seattle Sea Level Rise Plan

What challenges do rising sea levels pose?[24]

- Rising seas can erode shorelines around Puget Sound, make floods more severe, contribute to habitat loss, and allow salt water to enter bodies of fresh water.
- Dramatic sea level rise could force people to leave their homes and move elsewhere.
- Higher sea levels will lead to higher storm surges, leading to more flooding in more parts of the city and more salt water corrosion.
- Sea level rise can make it harder to drain stormwater from low-lying areas near Puget Sound, contributing to more urban flooding.



(Source: Seattle Public Utilities Sea Level Rise Map)

Who is most at risk in dealing with these challenges?

- People living and working in low-lying communities around Elliot Bay and the Duwamish River. Harbor Island, Georgetown, and South Park are particularly vulnerable.
- Park-goers that enjoy taking advantage of Alki Beach, Golden Gardens, and Seattle's many other public beaches on Puget Sound.

What can you do to prepare?

- Know the risk: Check out Seattle Public Utilities' Sea Level Rise Map, and NOAA's Sea Level Rise and Coastal Flooding Impacts Map to understand which areas of the city are most susceptible to damage from rising sea levels.

- Prepare for flooding: If you live in a low-lying neighborhood near the Sound or the Duwamish River, consider purchasing flood insurance. If a flood warning is issued, move valuable objects to upper floors and place sandbags to divert water away from your home in accordance with local laws. Seattle Public Utilities provides up to 25 free sandbags per household.[25]
- Have an evacuation plan: If storm surges might cause sudden flooding in your neighborhood, create an evacuation plan for you and your family.

OTHER CLIMATE PREPAREDNESS STRATEGIES

Get to know your neighbors[26]


(Source: City of Seattle)

Fostering social cohesion in your community is one of the best ways to promote resilience in the face of extreme weather and other climate challenges. When an extreme weather event takes place, residents and organizations in more connected communities can assist with supplies and help prevent displacement while identifying local needs for government officials. If you don't know them already, consider introducing yourself to people who live in your building or on your block; attend events or classes at your local community center, church, or school; throw a block party; form a book club; or take any other action you feel comfortable with to get to know your neighbors.

The City of Seattle offers many resources (including materials translated into 19 different languages) to help your neighborhood prepare for emergencies:

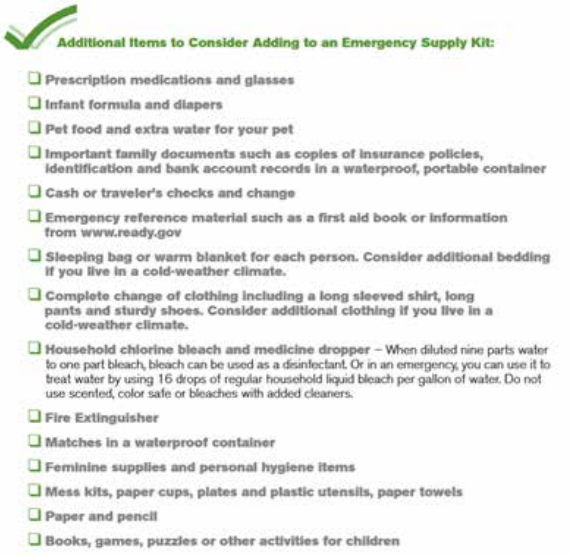
- AlertSeattle, a free emergency alert and notification system, that sends customized alerts via text and voice message, email, and social media. In addition to emergency alerts, you can also choose to receive customizable community notifications. These include notifications about severe weather, safety, health, utility disruptions, major traffic incidents, and more. Sign up for AlertSeattle online here.
- The Seattle Neighborhoods Actively Prepare (SNAP) program, which can help make sure everyone in your neighborhood is safe and cared for during extreme weather events and other emergencies. The SNAP online toolkit provides practical step-by-step instructions on organizing as a neighborhood, and the Office of Emergency Management can even come out to your home and talk with your neighbors about being prepared for kinds of hazards common to our area.
- Community Emergency Hubs. Hubs are groups of people who agree to meet at pre-determined locations following a major disaster to share information and resources, problem-solve, and support each other. Unlike a SNAP neighborhood, Hubs are larger

areas that encompass several neighborhoods. Find your nearest hub online here, or consider organizing your own.

Build and maintain an emergency kit[27,28]

Seattle is projected to see an increase in extreme weather events, like intense rainstorms or prolonged heat waves, as a result of climate change. In addition, our city's position near the Cascadia fault line presents an ever-present risk of a major earthquake. Disasters like these could potentially knock out utilities and other basic services for several days, so it is important to prepare a supplies kit in the event of an emergency. Just as important as building a kit is maintaining it: be sure to replace water and food supplies every six months. A minimum list of items to include is provided , but be sure to consider the needs of all your family members as you add and maintain the supplies in your kit. And don't forget your pets!

(Source: Ready.gov Basic Disaster Supplies Kit)



(Source: Ready.gov Basic Disaster Supplies Kit)

Take care of your health[29]

Climate change is increasing health risks for people in Seattle, including respiratory stress from poor air quality, heat stress during heat waves, and the spread of diseases through food, water, and animals. Just as macro level climate resilience can be thought of as maintaining a healthy immune system for our communities to bounce back when climate challenges strike, a healthy personal immune system can make you more resilient to personal impacts of climate challenges. Make sure you eat healthily, exercise regularly, and see a doctor to stay on top of any issues that might arise.

Become a citizen scientist

Humans continue to depend on the life-sustaining benefits and services provided by natural environments, but those natural ecosystems are threatened by climate change. In order to catalog and understand what the effects of climate change on our natural ecosystems look like, scientists need your help! The Seattle Aquarium, the Seattle Audubon Society, the Washington

Native Plant Society, and many more have opportunities for Seattle residents to get involved with important ecological monitoring projects. Plus, it's a fun way to get involved with your local community!

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