Council Meeting Date: August 3, 2020 **Agenda Item:** 8(b)

CITY COUNCIL AGENDA ITEM

CITY OF SHORELINE, WASHINGTON

AGENDA TITLE:	Discussing the Results of the Climate Impacts and Resiliency Study
DEPARTMENT:	Community Services Division
PRESENTED BY:	Autumn Salamack, Environmental Services Coordinator
ACTION:	____ Ordinance ____ Resolution ___ Motion _X__ Discussion ____ Public Hearing

PROBLEM/ISSUE STATEMENT:
On July 22, 2019, the City Council authorized the City Manager to execute a professional services contract with Cascadia Consulting Group to conduct a Climate Impacts and Resiliency Study. The study identified climate change impacts and areas of vulnerability for the City, with a core focus on the City's surface water system. Educational materials and a mapping tool were developed to communicate climate change-related vulnerabilities for our community and to support City staff in increasing resiliency in City projects and operations across all departments. The information gleaned from this study will be used to inform and help build resiliency features into future capital projects and planning efforts.

Tonight, Christy Shelton from Cascadia Consulting Group and Matt Fontaine from Herrera Environmental Consultants, will present the results of the Climate Impacts and Resiliency Study.

RESOURCE/FINANCIAL IMPACT:
A total of $79,992 was contracted with Cascadia Consulting Group for this project from the Surface Water Management Utility Fund.

RECOMMENDATION

No action is required by the Council tonight as this is a discussion Item only. Staff recommends that Council review the Climate Impacts and Resiliency Study and ask questions of staff and the City's consultants.

Approved By: City Manager ***DT*** City Attorney ***MK***

BACKGROUND

In December 2018, the City Council adopted the 2018 Surface Water Master Plan, which identified the current and future needs of the Surface Water Utility. One of the elements identified in this master plan as necessary for a long-term sustainable surface water system was a Climate Impacts and Resiliency Study. The 2018 Surface Water Master Plan states that “some areas throughout the City are already prone to flooding, so when planning improvement projects, the City must consider the increase of rainfall that the Puget Sound region is expected to have in the future. Special approaches should be considered to downscale regional climate models and model scenarios depicting extreme events, and to propose resiliency measures.”

On July 22, 2019, the City Council authorized the City Manager to execute Contract No. 9360 with Cascadia Consulting Group, Inc. (the Consultant) to conduct a Climate Impacts and Resiliency Study. The staff report for that action can be found at the following link:
http://cosweb.ci.shoreline.wa.us/uploads/attachments/cck/council/staffreports/2019/staffreport072219-7c.pdf.

The Climate Impacts and Resiliency Study was initiated in August 2019 and concluded in June 2020. The information gleaned from this study will be used to inform and help build resiliency features into future capital projects and planning efforts, including the next Climate Action Plan update.

DISCUSSION

The Climate Impacts and Resiliency Study identified climate change impacts and areas of vulnerability for the Shoreline community and developed materials to support City staff in increasing resiliency in City projects and operations across all departments. Staff from Public Works, Planning and Community Development, Parks, Recreation and Cultural Services, ASD (IT), and the City Manager’s Office attended two workshops with the Consultant. The purpose of those workshops was to refine the scope of the study, review and provide input on initial findings of the Climate Vulnerability Assessment and exposure analysis for local infrastructure, and collaboratively prioritize vulnerabilities relevant to the surface water system. This input helped guide development of resilience strategies and measures most relevant for the City.

The Climate Impacts and Resiliency Study report (Attachment A) provides detailed information on the study elements and deliverables, which included the following:

- Climate change projections for Shoreline using the latest available climate science information. This information was summarized in an “Observed Trends and Projected Climate Change Impacts for the City of Shoreline” memo (Attachment B).

- An assessment of climate change-related vulnerabilities for the Shoreline community using the four areas of risk identified in the climate change projections memo: temperature, precipitation, Puget Sound hydrology, and sea level rise.

This assessment looked at areas and degrees of vulnerability specifically within the following four sectors:

- The stormwater system;
- Buildings, development and transportation systems;
- Natural systems (such as ecosystems, parks, open spaces and natural areas); and
- Public health, safety and emergency services.

The results of the vulnerability assessment are shared in a series of five factsheets (Attachment C), and a public story map.

- A new mapping tool – the Climate Impacts Tool – developed to help City capital project managers and other staff easily identify areas of vulnerability and consider implementing measures to increase resilience to increased rain events and increased extreme heat events (Attachment A – Appendix A).

- A list of near-term actions to help build resiliency into the City's stormwater system and increase resilience of general infrastructure, natural systems, and the overall community (Attachment A – Appendix B).

- An evaluation of those actions (i.e. resiliency strategies) and their applicability to future City master planning efforts (Attachment A – Appendix C).

The information gleaned from this study will be used to inform and help build resiliency features into future capital projects and planning efforts. City staff will continue to identify how and when to best utilize the Climate Impacts Tool in capital project planning efforts. Educational materials developed during the study are available on the City's website (https://www.shorelinewa.gov/our-city/environment/sustainable-shoreline/climate-water-energy/adaptation-resilience) and will be shared with local educators and lead staff for City master planning efforts.

COUNCIL GOAL(S) ADDRESSED

This project addresses City Council Goal #2: Continue to deliver highly-valued public services through management of the City's infrastructure and stewardship of the natural environment, and specifically Action Step #7: Continue implementing the proactive strategy of the adopted 2017-2022 Surface Water Master Plan.

RESOURCE/FINANCIAL IMPACT

A total of $79,992 was contracted with Cascadia Consulting Group for this project from the Surface Water Management Utility Fund.

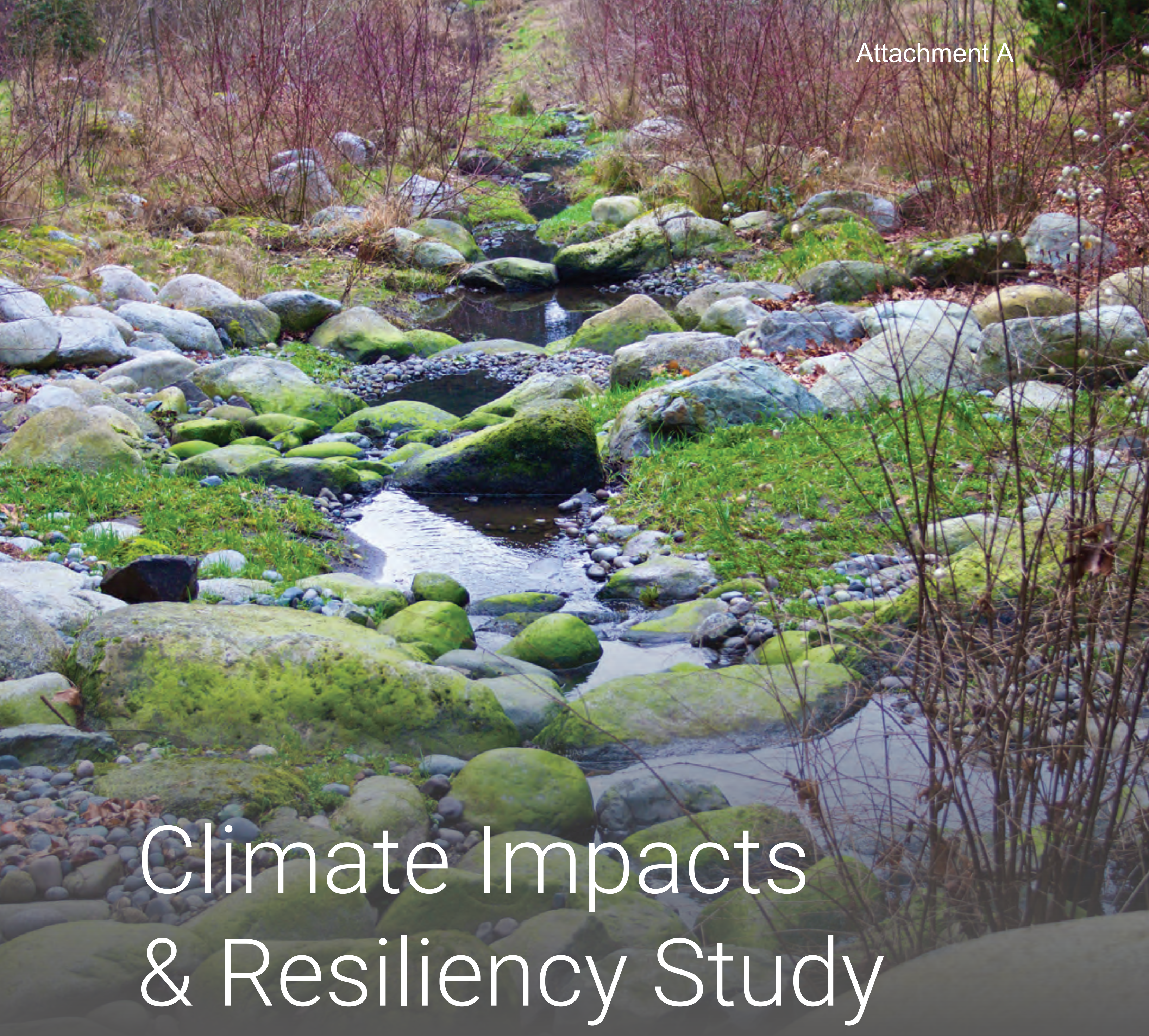
RECOMMENDATION

No action is required by the Council tonight as this is a discussion Item only. Staff recommends that Council review the Climate Impacts and Resiliency Study and ask questions of staff and the City's consultants.

ATTACHMENTS

Attachment A: Climate Impacts and Resiliency Study Report
Attachment B: Observed Trends and Projected Climate Change Impacts
Attachment C: Climate Vulnerability Assessment Factsheets

Attachment A



Climate Impacts & Resiliency Study

CITY OF SHORELINE

JUNE 2020

Prepared by Cascadia Consulting Group
and Herrera Environmental Consultants

CITY OF SHORELINE

INTRODUCTION

On July 22, 2019, the Shoreline City Council authorized the City Manager to execute Contract 9360 with Cascadia Consulting Group, Inc. to conduct a Climate Impacts and Resiliency Study ("Study"). Cascadia partnered with Herrera Environmental Consultants, Inc., who provided expertise around stormwater infrastructure and management, hydrological sciences, and spatial analysis. The study was initiated in August 2019 and concluded in June 2020. The study identified climate change impacts and areas of vulnerability for the Shoreline community, with a core focus on the City's stormwater system. Educational materials and a mapping tool were developed to communicate climate change-related vulnerabilities for our community and support City staff in increasing resiliency in City projects and operations across all departments. The information gleaned from this study will be used to inform, and help build resiliency features into, future capital projects and planning efforts, including the next Climate Action Plan update.

BACKGROUND

In December of 2018, the Shoreline City Council adopted the 2018 Surface Water Master Plan, which identified the current and future needs of the surface water system within City limits. The master plan identified a need for a Climate Impacts and Resiliency Study to help sustain a successful surface water system under changing conditions. The master plan states that “some areas throughout the City are already prone to flooding, so when planning improvement projects, the City must consider the increase of rainfall that the Puget Sound region is expected to have in the future. Special approaches should be considered to downscale regional climate models and model scenarios depicting extreme events, and to propose resiliency measures.” In sum, this study was a direct response to a need identified in the 2018 Surface Water Master Plan.

CLIMATE CHANGE PROJECTIONS

The consultant developed climate change projections using the latest available climate science information (as of October 2019) from academic literature, research organizations, and other institutions. City-specific projections were not available for all areas of focus, so projections at a regional scale were often utilized.

Climate change projections help us understand how human-caused greenhouse gas (GHG) emissions—the gases from burning fossil fuels like coal and oil for cars, trucks, planes, heating buildings and other activities—affect our global climate. Scientists use complex models to generate projections, which consider many factors—such as technological advancements, population growth, economic development, and changes in energy sources and land use—that influence global GHG emissions. The models show what might happen in the future based on different scenarios under which GHG emissions increase to different degrees.

Climate change projections were analyzed to understand impacts on temperature (annual, seasonal, and extremes), precipitation (annual, seasonal, and extremes), Puget Sound hydrology (snowpack and streamflows), and sea level rise.

The observed trends and projected changes in climate were summarized in a memo available on the City's website at: www.shorelinewa.gov/home/showdocument?id=46886. Figure 1 provides the key findings from analysis of climate change projections. The findings suggest that climate change has been occurring for decades and is expected to both increase existing challenges and create many kinds of new challenges in the future. The findings also suggest that key areas of risk for the Shoreline community include increased precipitation and more intense rainstorms, with associated flooding, increased temperatures, and extreme heat events. Decreasing snowpack and lower summer streamflows in the broader region may also negatively affect the Shoreline community's potable water supply, which comes from the mountain-fed Tolt and Cedar River watersheds. Risk from sea level rise is relatively low due to steep coastal bluff topography, the scarcity of development directly along the Puget Sound coast, and the BNSF railway acting as a buffer.

Figure 1. Findings from analysis of climate change projections

Temperature	The average year in Puget Sound is currently 1.3°F warmer than historic averages.	**By the 2050s (vs 1970-1999 average)** Average annual temperature in Puget Sound will be 4.2°F to 5.5°F warmer. The hottest summer days will be 4.0°F to 10.2°F warmer.
Precipitation	Extreme rain events in Western Washington have increased moderately.	**By the 2080s (vs 1980s)** Annual precipitation in Puget Sound will increase at least 6.4 percent. Rainstorms in Shoreline will be more intense. Winters will be wetter and summers drier.
Puget Sound Hydrology	Puget Sound rivers have lower streamflows during the summer, and streamflow peaks earlier in the year, leaving streams drier in late summer and fall.	**By the 2080s (vs 1970-1999 average)** Summer streamflows will be even lower. Flooding risk will increase during the fall, winter, and spring. The Tolt and Cedar River watersheds (which supply Shoreline's drinking water) will have less snowpack to source water from.
Sea Level Rise	Sea level has risen 0.8 inches per decade in Puget Sound between 1900-2009.	**By 2100 (vs 1991-2001 average)** Relative sea level in Shoreline will rise 2.0 feet or more, resulting in greater risk of coastal erosion and flooding.

VULNERABILITY ASSESSMENT

The consultant completed an assessment of climate change-related vulnerabilities for the Shoreline community using the four areas of risk identified in the climate change projections memo (temperature, precipitation, Puget Sound hydrology, and sea level rise). The assessment identified, categorized, and prioritized climate change vulnerabilities based on exposure, sensitivity, and adaptive capacity. Figure 2 defines these key components and indicates how they affect vulnerability. Vulnerability was assessed in four sectors across the community, which are listed in Figure 3.

During the vulnerability assessment process, staff from Public Works; Planning and Community Development; Parks, Recreation and Cultural Services; ASD (IT); Community Services; and the City Manager's Office attended two workshops with the consultant team to refine the scope of the study, review and provide input on initial findings of the climate vulnerability assessment and exposure analysis, and collaboratively prioritize vulnerabilities relevant to the surface water system. This input helped guide development of resilience strategies most relevant for the city.

Figure 2. Defining key components of vulnerability

What is vulnerability?

It is a function of the exposure of a system to impacts from climate change, its sensitivity to those impacts, and its capacity to adapt to prepare for those impacts.

Exposure

The portion of the community in harm's way due to climate impacts.

INCREASES VULNERABILITY

Sensitivity

The degree to which the community is affected by climate impacts.

INCREASES VULNERABILITY

Adaptive Capacity

The City's and community's actions to prepare for climate impacts.

DECREASES VULNERABILITY

Figure 3. Sectors and systems evaluated in the vulnerability assessment

Natural Systems: Parks & Open Space; Urban Trees; Sensitive Ecosystems

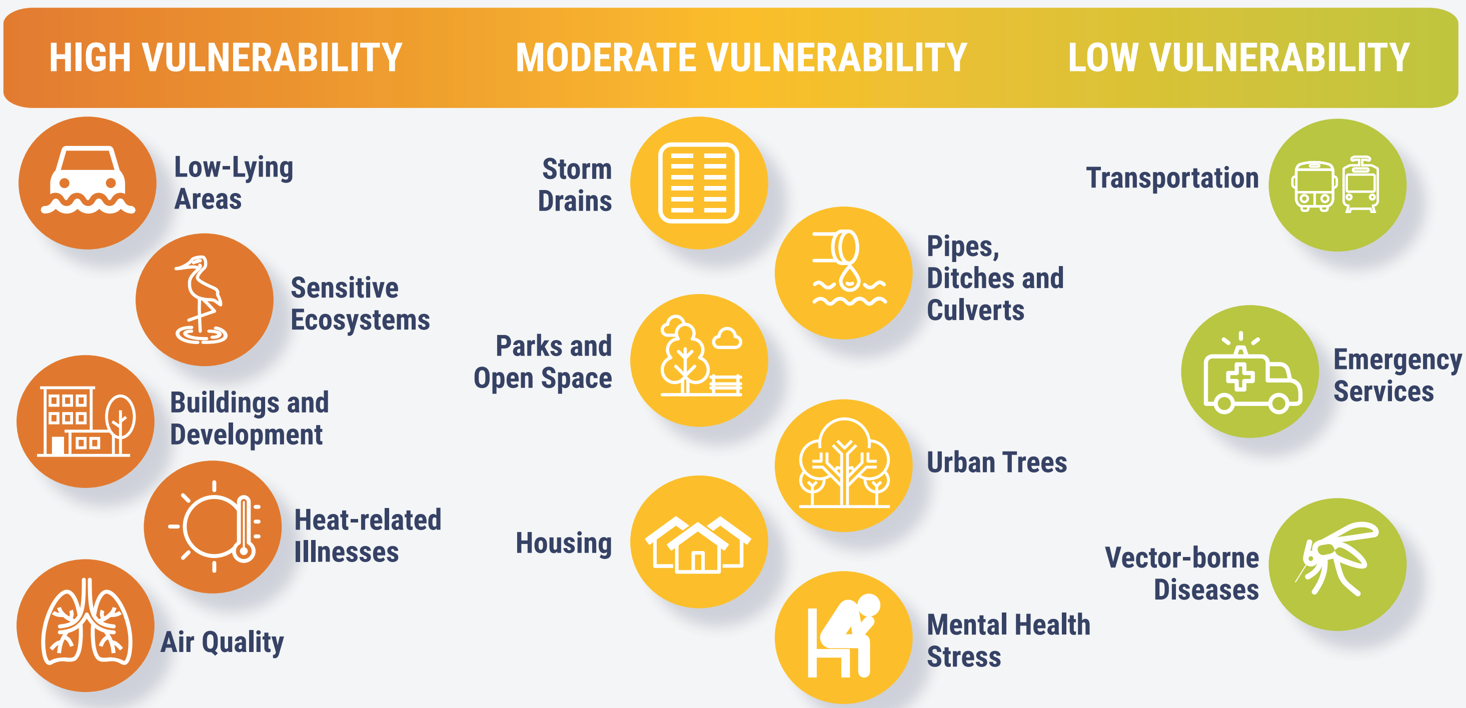
Built Environment: Housing; Transportation; Buildings & Development

Stormwater: Low-lying Areas; Storm Drains; Stormwater Pipes, Ditches, & Culverts

Public Health, Safety & Emergency Services: Heat-related Illnesses; Air Quality; Mental Health; Emergency Services; Vector-borne Diseases

Figure 4 summarizes the high-level findings about areas and the relative magnitude of vulnerability to climate change impacts across the Shoreline community. Detailed results from the assessment are provided in a series of five factsheets available for reference by City staff and the community on the City's website at: http://www.shorelinewa.gov/our-city/environment/sustainable-shoreline/climate-water-energy/adaptation-resilience.

Figure 4. Sector-specific vulnerabilities to climate change in Shoreline



How **climate impacts and related risks** affect **key areas of vulnerability**

More frequent heavy rainstorms

Increased flooding risk

More extreme heat and drier summers

Reduced air quality from heat & wildfire smoke risk

Low-Lying Areas

High vulnerability because low-lying areas are more likely than other parts of the City to be flooded during larger rainstorms, and ways to address these problems are expensive.

Sensitive Ecosystems

High vulnerability due to existing stress from human activities and the complex challenge of restoring natural systems. Wetter winters and hotter, drier summers may further stress wetlands, water bodies, and other ecosystems and the threatened and endangered fish and wildlife that inhabit these areas.

Buildings and Development

High vulnerability due to the need to prevent impacts of higher temperatures and increased flooding risk in the context of redevelopment and a growing population.

Heat-related Illnesses

High vulnerability due to the need for resources to protect residents from exposure to extreme heat. More extreme temperatures may increase risk of heat-related illnesses, especially in areas with more paved surfaces that absorb heat.

Air Quality

High vulnerability due to the need for preventative measures and more treatment for people affected by allergies and wildfire smoke. Warmer temperatures and higher risk of wildfire smoke may cause more pollution and reduce air quality.

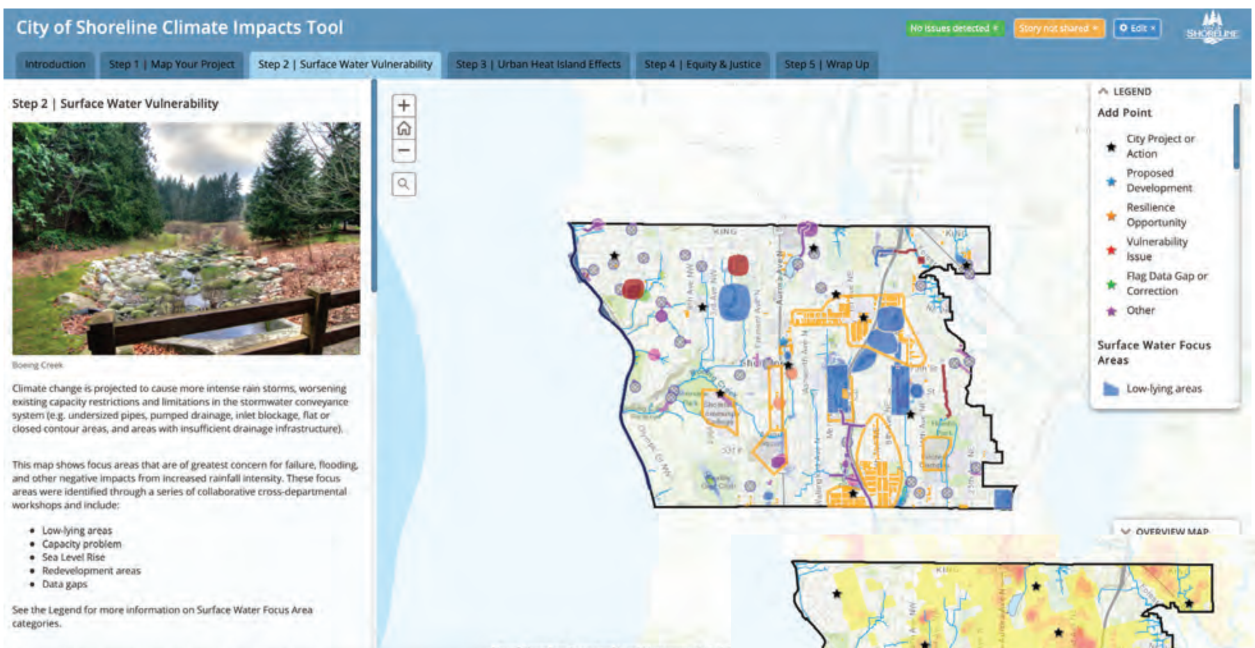
CLIMATE IMPACTS TOOL

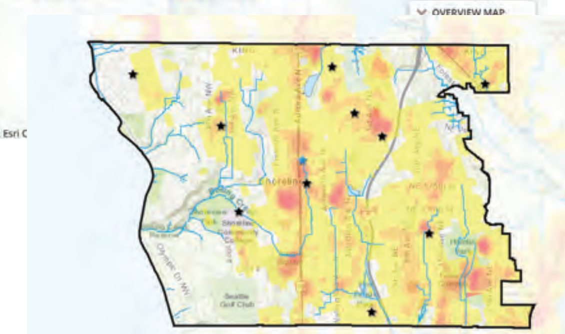
The consultant team drew information from the vulnerability assessment to create a new map-based geographic information system (GIS) tool to help City capital project managers and other staff easily identify current or future areas that are vulnerable to climate change impacts and consider implementing measures to increase resilience to these impacts (see Appendix A).

This tool includes interactive maps with instructions to navigate project managers through a series of steps to address three key topics: 1) Surface Water Vulnerabilities, 2) Urban Heat Island Effects, and 3) Equity and Justice. The tool provides suggestions for adaptive solutions to combat increased rain events and increased extreme heat events in the City. The tool also provides information about socio-economic data in project areas to help inform project design and community engagement.

The tool was shared with six staff from Public Works for testing. In addition to submitting feedback forms, the testers were invited to a debriefing session to provide additional feedback. This information was used to update the tool to improve its usability and functionality. The tool is expected to evolve over time as Public Works and IT staff needs and resources change in the future. Figure 5 includes static images of the Climate Impacts Tool.

Figure 5. Static images of the Climate Impacts Tool





Map of urban heat islands in Shoreline.

RESILIENCY STRATEGIES

The consultant team used the vulnerability assessment as well as their expertise and best management practices to develop a list of near-term actions (within the next six years) that are focused on building resiliency into the City's stormwater system, as well as increasing resilience of general infrastructure, natural systems, and the overall community. The consultant team also developed an accompanying framework for prioritizing resiliency strategies for Shoreline's unique context based on agreed upon criteria (see Appendix B): effectiveness and impact, ease of implementation, co-benefits, urgency, and equity.

City staff reviewed the suite of strategies and prioritization values and collaborated with the consultant team to revise and finalize the set of prioritized strategies. The high priority resiliency strategies are listed below.

- Require capital facilities planning to consider opportunities to increase resiliency using the Climate Impacts Tool.
- Modify standards for stormwater facility sizing to increase capacity and ensure adequacy of flow control and water quality treatment facilities.
- Modify design standards for drain inlets to increase capacity.
- Build retrofit-focused regional stormwater facilities.
- Revise tree list and green stormwater infrastructure planting requirements to be more resilient.
- Modify urban design standards to ensure development increases city-wide climate resilience.

Master Plan Alignment

Resiliency strategies were evaluated in terms of applicability to City master planning efforts including: Comprehensive Plan; Climate Action Plan; Transportation Master Plan; Surface Water Master Plan; Parks, Recreation, and Open Space Plan; Ronald Wastewater District Comprehensive Plan; and Economic Development Strategy. This analysis will be shared with lead staff for each plan for consideration in future master planning updates (see Appendix C).

Common opportunities for advancing resiliency strategies across master planning processes include:

Proactively collect data and map areas with flooding or other stormwater vulnerabilities and/or urban heat island vulnerabilities when conducting any inventory or data collection for the specific master planning process to improve the City's ability to evaluate stormwater system deficiencies, improve system resilience, and protect critical areas.

Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool.

Construct more green stormwater infrastructure (GSI) through new construction, retrofit programs, and/or policies to include GSI on City projects.

Develop a framework for public and private partnerships that works toward a more resilient city through stormwater management strategies that increase green space, habitat connections, and mobility.

Increase tree plantings of species that will be more resilient to climate impacts in open spaces, parks, along roads and trails, and other areas. Co-benefits include more resilient urban habitat, expanded urban forest canopy, reduced urban heat island effect, and greenhouse gas emissions mitigation.

Consider modifying design standards citywide to ensure that future development increases resilience to climate change.


Climate Change and the City of Shoreline

Edit story

Climate Change and the City of Shoreline

Introduction

The City of Shoreline's 2013 Climate Action Plan outlined a series of actions to reduce greenhouse gas (GHG) emissions and reduce future climate impacts for the Shoreline community. While we must continue to reduce GHG emissions, we must also prepare our community for climate impacts that are here now and anticipated in the future.

Scroll down to read about how our local and regional climate has changed historically and how it is projected to change in the future in terms of temperature, precipitation, flooding, and sea level rise.

How will climate change impact the City of Shoreline?

Risk	Trends to Date	Projected Changes
Temperature	The average year in the Puget Sound region is currently 1.3°F warmer than historic averages.	**By the 2050s (vs 1970-1999 average)** Average annual temperature in the Puget Sound region will be 4.2°F to 5.5°F warmer. The hottest summer days will be 4.0°F to 10.2°F warmer.
Precipitation	Extreme rain events in Western Washington have increased moderately.	**By the 2080s (vs 1980s)** Annual precipitation in the Puget Sound region will increase at least 6.4 percent. Rainstorms in Shoreline will be more intense. Winters will be wetter and summers drier.
Puget Sound Hydrology	Puget Sound rivers have lower streamflows during the summer, and streamflow peaks earlier in the year, leaving streams drier in the late summer and fall.	**By the 2080s (vs 1970-1999 average)** Summer streamflows will be even lower. Flooding risk will increase during the fall, winter, and spring. The Tolt and Cedar River watersheds (which supply Shoreline's drinking water) will have less snowpack to source water from.
Sea Level Rise	Sea level has risen 0.8 inches per decade in Puget Sound between 1900-2009.	**By 2100 (vs 1991-2001 average)** Relative sea level in Shoreline will rise 2.0 feet or more, resulting in greater risk of coastal erosion and flooding.

Urban Heat Islands

Hotter temperatures in a changing climate are especially concerning for urban heat islands. Urban heat islands are areas where roofs, pavement, and other dark-colored hard surfaces absorb heat and cause some areas of a city to be warmer compared to shaded or vegetated areas, like forested parks or surrounding rural landscapes. Urban heat islands are already occurring in Shoreline and many other cities. As temperatures rise under climate change, people, plants, animals, and infrastructure in urban heat islands may be more vulnerable to extreme heat.

Scroll down to see a map of urban heat islands in Shoreline.

Scroll down to read about areas of vulnerability for our community.

EDUCATIONAL MATERIALS

The consultant worked with City staff to develop public-facing educational materials to communicate areas of climate change-related vulnerabilities and opportunities for increasing resiliency. In addition to the climate change projections memo and sector factsheets, the consultant developed a public story map available at https://arcg.is/081zPC0. The story map was designed to communicate the vulnerability assessment results in a simple format and present a high-level overview of the type and magnitude of risk for the community. The story map also highlights a few of the steps the City has already taken to prepare for a changing climate, such as modeling the capacity of the stormwater system to identify weaknesses and areas most sensitive to more rainwater due to climate change and prioritize projects for improvements (e.g., larger pipes).

The story map, factsheets and memo were posted on a new Adaption & Resilience page on the City website and are all available for reference by the Shoreline community at www.shorelinewa.gov/our-city/environment/sustainable-shoreline/climate-water-energy/adaptation-resilience.

NEXT STEPS

The information gleaned from the Climate Impacts and Resilience Study will be used to inform, and help build resiliency features into, future capital projects and planning efforts. City staff will continue to identify how and when to best utilize the Climate Impacts Tool in capital project planning efforts. Educational materials developed during the study will be shared with local educators and with lead staff for City master planning efforts. The vulnerability assessment conducted for this study will also lay a foundation for the City's Climate Action Plan update, which is anticipated to occur in 2021-2022, by providing information on anticipated climate impacts and local vulnerabilities to inform the development of adaptation and resilience-building measures communitywide.

APPENDICES

- Appendix A: Climate Impacts Tool summary
- Appendix B: Recommended resilience strategies
- Appendix C: Resiliency strategies and master plans

Appendix A.
Climate Impacts Tool summary

CITY OF SHORELINE

APPENDIX A: CLIMATE IMPACTS TOOL SUMMARY

The new Climate Impacts Tool was developed to help capital project managers easily identify current or future areas of vulnerability related to climate change. This mapping tool identifies areas that are vulnerable to climate change impacts and provides suggestions for adaptive solutions to address three key topics:

- Surface Water Vulnerabilities;
- Urban Heat Island Effects; and
- Equity and Justice.

The tool includes interactive maps with instructions to navigate projects through five steps. The tool also outlines potential resilience measures to combat increased rain events and increased extreme heat events in the City of Shoreline. Details of the five steps in the tool are below.

Step 1 | Map Your Project

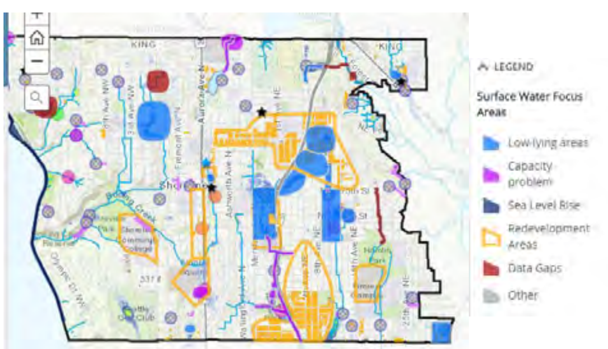
An interactive map allows project managers to add their capital project as a point on the map. This project point is then visible when assessing vulnerabilities and opportunities in subsequent steps.

Step 2 | Surface Water Vulnerabilities

A map shows areas that are of greatest concern for failure, flooding, and other negative impacts from increased rainfall intensity (Figure 1). These focus areas were identified through a series of collaborative cross-departmental workshops and include:

- Low-lying areas;
- Capacity problems;
- Sea level rise;
- Redevelopment areas (i.e. areas that may have more impervious surface in the future); and
- Data gaps.

Figure 1: Surface Water Vulnerabilities



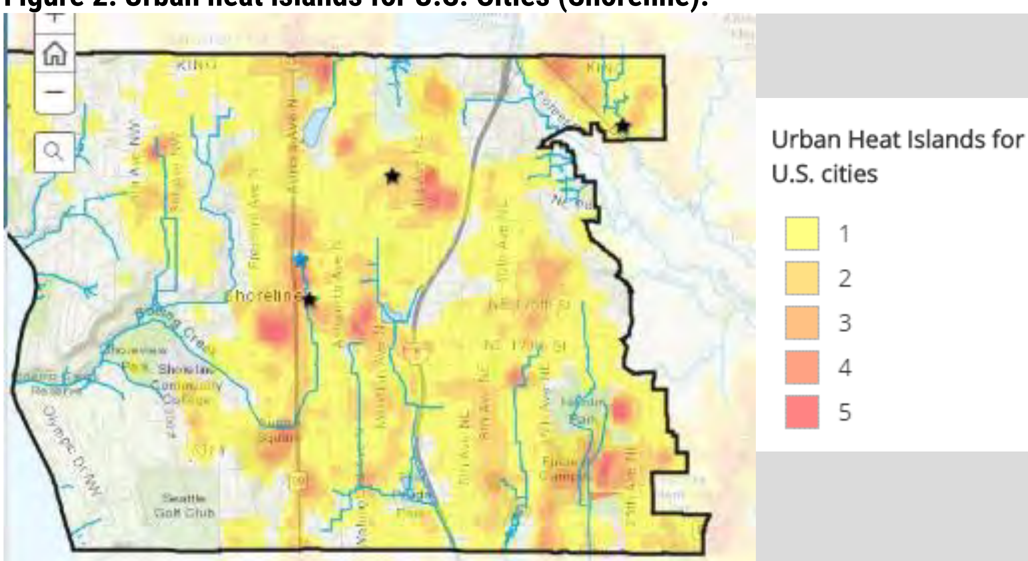
The map also identifies resiliency measures for project managers to consider incorporating into projects to improve surface water management and reduce flooding risks.
Figure 1: Surface water focus areas in Shoreline. Please note that the stars in all maps in this document represent project sites entered during testing for the tool.

Step 3 | Urban Heat Island Effects

Urban heat islands are areas where roofs, pavement, and other dark-colored hard surfaces absorb heat and cause some areas of a city to be warmer compared to shaded or vegetated areas, like forested parks or surrounding rural landscapes.

This map shows areas in Shoreline that are hotter than average city temperatures (Figure 2). It uses a scale of 1 as a mild heat area (yellow) to 5 as a severe heat area (red). As temperatures rise due to climate change, people, plants, animals, and infrastructure in urban heat islands may be more vulnerable to extreme heat. Some populations that may be more vulnerable to extreme heat include people who are very old or very young, have respiratory illness, work outdoors, or experience homelessness. The map also identifies resiliency measures for project managers to consider incorporating into projects to add shade, reduce surface types that enhance the urban heat island effect, and promote cooling.

Figure 2: Urban heat islands for U.S. Cities (Shoreline).



Step 4 | Equity and Justice Considerations

Climate change impacts will disproportionately affect vulnerable groups in our community. People with existing health conditions, who are very old or very young, or have few social connections may all experience greater physical and mental health impacts from climate change. Equitable climate resilience requires meaningful community engagement and relationship building that should be considered from the very start of a City project.

This map shows equity data from the U.S. Census Bureau's American Community Survey (ACS) 5-year estimates (Figures 3-7). The map displays data for Shoreline's census block groups for the following topics to highlight how a project might affect vulnerable and marginalized populations.

- People of Color: The population that does not identify as White/Non-Hispanic. This includes: Black, American Indian/Alaskan Native, Asian, Native Hawaiian-Other Pacific Islander, two or more races and the ethnicity grouping of Spanish/Hispanic/Latino. Definition drawn from the Washington Tracking Network.
- Limited English-Speaking Households: The percent of households with self-reported limited English-speaking ability, as defined by the ACS.
- Households with People with Disabilities: Any household with a self-reported member who has one of six disability types defined by the ACS: hearing difficulty, vision difficulty, cognitive difficulty, ambulatory difficulty, self-care difficulty, and independent living difficulty.
- Households of One Person 65 Years or Older: The percent of households with only one person living in it and that person is aged 65 years or older.
- Median Per Capita Income: The median annual income on an individual level for all residents in a census block group.

Equity considerations are unique to each project, community, individual, and location, so there isn't a single set of recommendations that will make all projects more equitable. Instead, the map provides a series of questions to help project managers look for opportunities to address equity in their project design, implementation and outreach strategies.

Figure 3: People of color mapping in Shoreline.

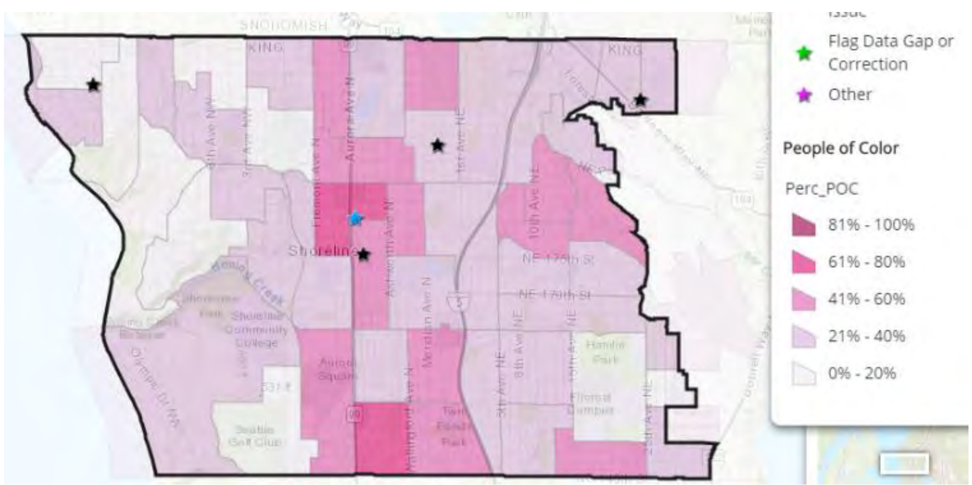


Figure 4: Limited English-speaking households in Shoreline.

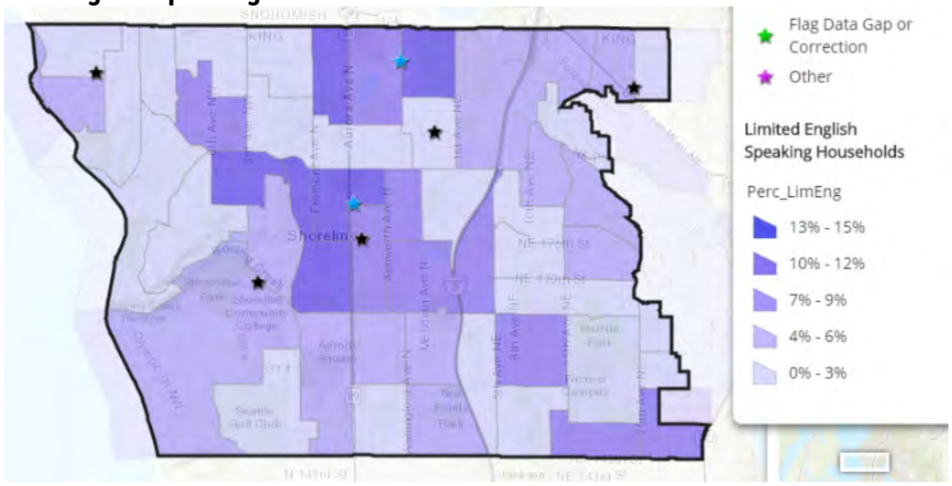


Figure 5: Shoreline households with members with disabilities.

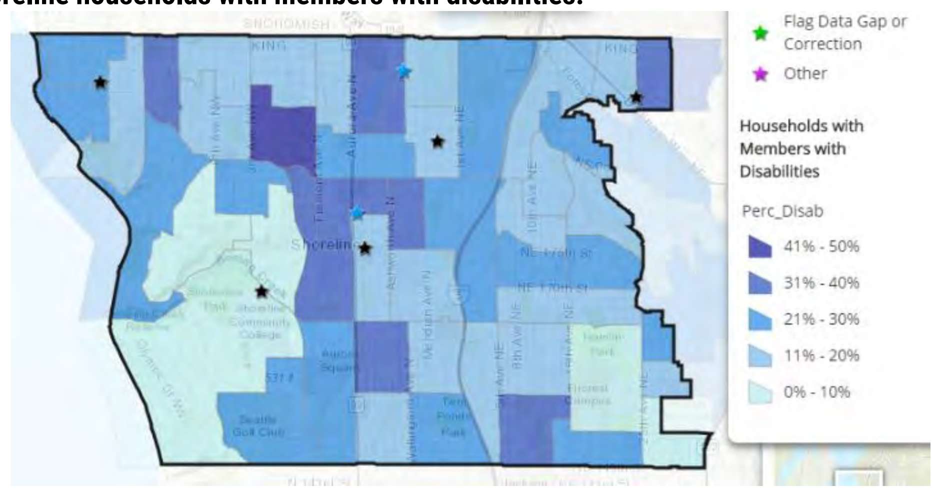


Figure 6: Shoreline households of one person 65 years or older.

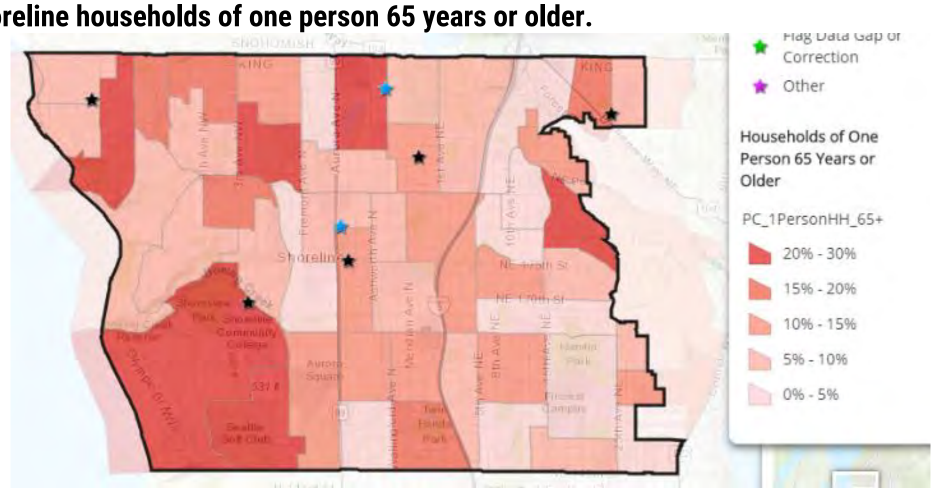
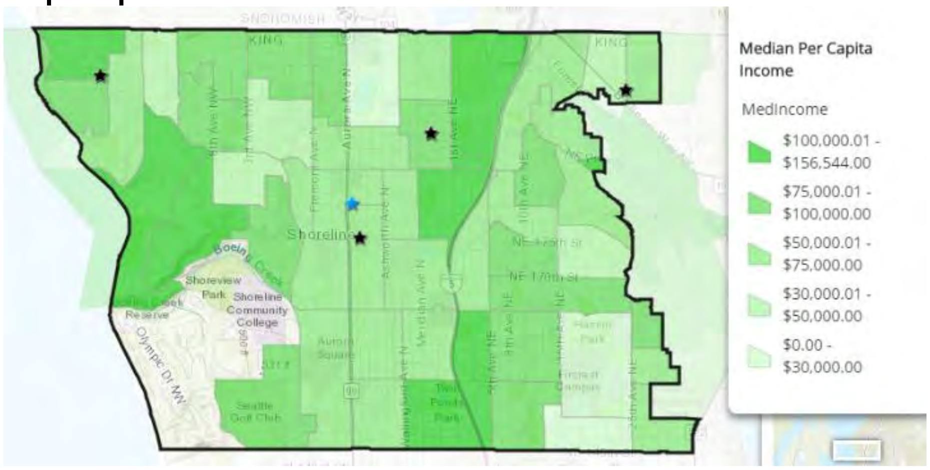


Figure 7: Median per capita income in Shoreline.



Step 5 | Wrap Up

All capital project managers should add their projects to the mapping tool, walk through each step of the tool, and record their assessment of vulnerabilities – and opportunities to address those vulnerabilities – in the project charter. Project managers should also answer the following questions in their project charter:

1. When did you use the Climate Impact Tool for this project?
2. Is your project located in an area with surface water vulnerabilities identified? If so, which vulnerabilities are of concern? What actions are included in project design to address these vulnerabilities?
3. Is your project located in an area of concern for urban heat island effects? If so, how significant is that concern (on the map scale of 1-5)? What actions are included in project design to address this vulnerability?
4. What equity and justice data from the map pertains to your project? How will you incorporate the City's "Meaningful Community Engagement Guide" process into your project?

If a project does not have a charter, the project manager should answer the questions above and incorporate the applicable climate vulnerability considerations and resilience recommendations into any relevant project scope, planning, preliminary design, and/or design documents.

Next Steps

For each vulnerability identified in the map, there are many types of capital project and associated resilience measures that could be implemented. It is not currently possible, nor necessarily better, to provide a prescriptive menu of all potential actions for project managers to consult. Rather, this tool represents a first step for project managers to analyze and reflect on the information presented. It encourages critical thinking to assess vulnerabilities and resilience opportunities when designing the project and community engagement. Staff anticipate reviewing tool outcomes and resulting strategies implemented by staff after the first 6-12 months to identify successful resilience strategies to potentially share with other project managers in the future.

This tool will likely evolve over time in partnership with Public Works and IT staff needs and resources.
Additional conversations are also needed with staff in Public Works to discuss the questions listed below regarding the best use of this tool.

- When should this tool be used – during project prioritization discussions or once a project is assigned to a project manager?
- If resilience strategies are identified for a project, what is an acceptable cost increase to ensure they are implemented?
- Are there specific policies to be implemented in capital projects based on mapping results? For example, if a project will be located in an area already identified as a 4 or 5 on the urban heat island map, and the project will likely exacerbate that effect, does it becomes a requirement to mitigate that increase in heat in the project design (vs. a strong recommendation to consider adjustments if the area is only identified as a 1 or 2)?

For more information about this tool, please contact Autumn Salamack at asalamack@shorelinewa.gov, or John Featherstone at jfeatherstone@shorelinewa.gov.

Appendix B.
Recommended resilience strategies

APPENDIX B: RECOMMENDED RESILIENCE STRATEGIES

The consultant-recommended resilience strategies below will be reviewed with City staff in various departments to ascertain feasibility and alignment with existing plans and efforts.

Policies and Regulatory Changes

1. **Hazards |** Evaluate the development code related to landslide hazards to reduce risk. This action should be preceded by a detailed assessment and improved mapping of hazard areas (see Data Collection under City Programs and Services).
2. **Partnership |** Develop a framework for public and private partnerships that work towards a more resilient city through stormwater management strategies that increase green space, habitat connections, and mobility. Examples might include:
    - Green space management planning and permitting to streamline the City permitting process and facilitate climate-resilient best management practices for privately-owned and managed green spaces.
    - Opportunities for stormwater system easements to create habitat networks or to connect ecosystem services.
    - Opportunities to leverage green stormwater infrastructure (GSI) to expand and connect pedestrian/bicycle path networks for alternative transportation routes, including connections to the Interurban Trail.

City Programs and Services

3. **Street Sweeping |** Evaluate the street sweeping program to identify changes to sweeping locations, timing, and frequency that could increase resilience to climate change and equity, particularly reducing the likelihood that drain inlets clog during large storms and the potential to improve water quality in surface water bodies in the city, and potential benefit to benefit vulnerable populations. Expand or modify the street sweeping program based on the findings. Note that efforts to expand the urban forest canopy may contribute additional leaf litter that could clog storm drain inlets.
4. **Data Collection |** Implement proactive data collection and mapping of stormwater system components and critical areas to improve the City's ability to evaluate stormwater system deficiencies, improve system resilience, and protect critical areas (streams, wetlands, and geologic hazard areas). Improved hazard mapping (especially for slide areas) is recommended because seasonal changes in rainfall could impact the sensitivity of slide-prone areas.
    - Note: Some areas have been identified as "Data Gaps" in the Climate Impacts Tool. Notes associated with these locations indicate the type of data gap (e.g., flow monitoring, system investigation/mapping) that should be addressed to better understand flooding risks and identify possible improvements. The Climate Impacts Tool could be used to identify additional data gaps and to resolve all gaps.

5. **Regional Stormwater Facilities |** Plan and construct regional stormwater facilities to protect surface water bodies by providing flow control and/or water quality treatment. The City can take two primary approaches to regional stormwater facilities:
    a. Redevelopment-focused regional stormwater facilities, i.e. those that are located downstream of areas that are expected to experience significant redevelopment. Redevelopment-focused facilities would be constructed to serve redevelopment in-lieu of, and generally equivalent to, onsite stormwater management.
    b. Retrofit-focused regional stormwater facilities, i.e. those that are focused toward providing the maximum stormwater benefits downstream of developed areas, regardless of whether the tributary area is likely to experience significant redevelopment. Retrofit-focused facilities have more flexibility to be located in places that maximize the benefit to surface waters, flood reduction, and equity.

    Either type of regional facility could be funded through a fee-in-lieu system and sited and designed to increase climate resilience; however, the two approaches have different advantages:
    - Redevelopment-focused facilities are likely to be reimbursed more quickly through a fee-in-lieu system, and therefore, less costly/risky for the City.
    - Retrofit-focused facilities have greater flexibility with siting and design, and therefore, can have more flexibility to maximize climate resilience benefits. The NPDES Phase II Municipal stormwater permit may require structural stormwater controls in the future and retrofit-focused facilities would satisfy that requirement.
6. **Capital Facilities Planning |** Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool. This should be documented in the upcoming Project Manager Manual. As more information becomes available on stormwater system capacity and flooding problems, add this information to the Climate Impacts Tool.
7. **Proactive Maintenance Staffing |** Forecast City GSI installations to anticipate maintenance personnel shortages in the future, because GSI requires specialized maintenance and can be maintenance intensive. Incorporate any necessary increases in staffing into the next Surface Water Master Plan update and surface water utility rate assessment.
8. **More GSI |** Construct more GSI through retrofit programs or policies to include GSI on City projects. Retrofit planning for GSI could include identifying priority areas based on downstream system capacity limitations and aquatic resource prioritization. Continue to evaluate and modify codes and/or standards to make GSI the preferred choice for development. Target grant applications to support projects that plan and implement GSI retrofits. If possible, coordinate with sidewalk, bike lane, and other mobility improvements in the ROW. Develop GSI Design Standards, such as standard plans, details, and specifications with a focus on consistency, function, and consideration of climate impacts.
9. **Soak-it-Up Rebate Program |** Expand the Soak-it-Up program to further incentivize construction of GSI facilities. Improve the program to be more equitable, potentially through grants, targeted outreach and education, and actions that can benefit disadvantaged, including approaches that benefit individuals that don’t own property.

10. **Retrofit Drain Inlets |** Identify high-priority inlets and implement a retrofit program to upgrade inlets for improved capacity. Consider equity issues when identifying the high-priority inlets.
11. **Manage Lake Eutrophication |** Rising temperatures may exacerbate water quality challenges associated with lakes. Evaluate the causes of lake eutrophication and proactively develop and implement lake management plans to include additional upstream stormwater requirements, stormwater retrofits, and/or in-lake remediation activities, depending on the identified causes.
12. **Evaluate Sea Level Rise |** Evaluate sea level rise in greater detail and develop strategy to address potential impacts to surface water outfalls, City property and park facilities, and private property.

Engineering Standards and Design Standards

13. **More Robust Downstream Analysis Requirements |** Develop more robust requirements for downstream analysis, including identification of existing stormwater problem areas. For example, Chapter 1 of the King County Surface Water Design Manual (KCSWDM) includes a section on Downstream Drainage Problems Requiring Special Attention. The KCSWDM lists four problem categories: (1) conveyance system nuisance, (2) severe erosion, (3) severe flooding, (4) potential impacts to wetland hydrology. The City could develop and adopt similar requirements to trigger special stormwater mitigation in places where existing problems are most severe.
14. **Drain Inlets |** Modify design standard to require combination inlets or dual inlets under certain conditions (e.g., sags in the roadway, areas with history of clogging or capacity-related flooding, areas with significant tree canopy) to increase capacity for higher-intensity storm events and reduce the risk of clogging. Increased inlet capacity may result in additional debris in the downstream pipe network, which can be partially offset by preventative programs such as street sweeping.
15. **Stormwater Facility Sizing |** Modify the standards for design of conveyance, flow control, and treatment facilities. Examples are given below.
    - Conveyance: Require application of a climate change safety factor on design flows used in conveyance sizing (near term).
    - Flow control and treatment facilities: Require analysis using a precipitation timeseries that has been modified to account for climate change impacts after a regionally accepted standard of practice has been defined (longer term).
16. **Resilient Planting |** Revise tree list and GSI planting requirements to create more resilient urban habitat and expand urban forest canopy. Based on a high-level review of the current tree list, preliminary suggestions include the following. Please note that street trees have several constraints and a very specific and involved processes for updating the street tree list. The parties involved with that process have not been consulted in the development of these recommendations but will be consulted in reviewing these recommendations moving forward.
    - Plant species that will survive in the long-term and create larger, longer-lived urban canopy. In particular, increasing the diversity of tree sizes and tree genetics will help with pest resilience, canopy size, and adaptability to climate change. For example, Shoreline's current list has a lot of trees in the Rosaceae family (cherries,

crabapples, plums, pears), and while these are ornamental trees that fit in smaller planting spaces, they are weak-wooded, short-lived trees that are prone to pest issues and failure. Planting larger tree species as street trees where amenity zones are adequately wide will help with climate change resiliency in the future.

- Plant more evergreen trees. These species will improve water quality and catchment for stormwater, as well as increase carbon sequestration. Identifying places within the City that can accommodate larger conifers or broadleaf evergreen trees can help maximize the benefits of trees in the urban environment.
- Discuss removing trees from the list that are considered an invasive or nuisance species in King County or nearby areas. For example, horsechestnut is currently approved for planting in Shoreline, but it is a known nuisance tree and is likely to become more of an issue in the future.
- Remove tree species from the list that have ongoing pest problems. For example, the Himalayan Birch Betula jacquemontii has severe issues with a pest called Bronze Birch Borer and this species is currently dying en masse in multiple cities. Planting species vulnerable to pests is not a long-term solution to increasing urban canopy. Other types of birches or smaller deciduous trees that provide the same role should be considered for the approved tree list instead.
- Plant additional native trees, or native tree cultivars/ hybrids, to help support local habitat, fauna, and flora, and increase native canopy cover. Many of the trees on the current list are native to the East Coast, Europe, or Asia, and some of them have higher water needs in the summer than what is typical for the Pacific Northwest. Modifying the list to include native species will increase survival, reduce summertime water demand, and reduce maintenance needs over time.
- Discuss provenance of local seed sources for nursery material and experiment with obtaining tree stock from areas slightly south of Shoreline to monitor the adaptability of plant material from slightly warmer regions compared to stock sourced from areas north of the City or unknown seed sources.

17. **More Resilient Urban Design Standards |** Consider modifying design standards to ensure that future development increases city-wide resilience to climate change. As an example, modify design standards to encourage more vegetation and large trees. In addition to stormwater benefits, vegetation can improve urban habitat and provide shading to mitigate urban heat island effects.

PRIORITIZATION FRAMEWORK

This prioritization framework is intended to enable qualitative prioritization of the climate change resilience strategies for surface water. See above for a complete description each strategy. Each strategy was ranked as high, moderate, or low for each criterion. The "Criteria Definitions" table below provides more information on each criterium. An overall priority was assigned for each strategy based on qualitative consideration of all criteria. "High" strategies are highlighted in green below.

Resilience Strategy		Prioritization Criteria					Overall Priority
		Effectiveness and Impact	Ease of Implementation	Strategy has Co-benefits	Urgency	Equity	
		How much will the strategy increase resilience? How large are the potential cost/damages that could result from inaction?	*How affordable is the action given current staffing levels and budget? Is the action in line with current policies, regulations, and/or technology?*	*Does the strategy address multiple goals, or other City or community objectives?*	*How short is the window of opportunity? How quickly will the cost of inaction start accruing?*	*Does the action address the needs of vulnerable and historically marginalized populations?*	
Policies and Regulatory Changes							
1	Evaluate **landslide hazard risk** in development code	*Moderate* Only benefits a small area of the city but landslides are very damaging.	*Moderate* Will require a significant amount of staff time and/or external support, but there are no regulatory or technological barriers to implementing this strategy.	*Low* Strategy doesn't address other City goals or objectives.	*Low* The timing of landslides is difficult to predict and there is significant uncertainty surrounding how much climate change will affect the risk or frequency of landslides in the City.	*Moderate* Neither harms nor benefits vulnerable populations.	**Low**
2	Develop framework for **public-private partnerships** to support resilience	*Moderate* Moderate benefits to natural systems and mobility.	*Low* Historically public-private partnerships have been very time intensive for City staff to manage.	*High* Strategy addresses goals and objectives related to stormwater, natural systems, and mobility.	*Moderate* Redevelopment around light rail stations has begun. There are many public private partnership opportunities outside the light rail station area.	*Moderate* Neither harms nor benefits vulnerable populations.	**Moderate**
City Programs and Services							
3	Expand **street sweeping** program	*Moderate* The City currently has a robust sweeping program. This action would expand or fine tune the sweeping program to increase effectiveness, reduce drain inlet clogging and improve water quality.	*Moderate* May require more up front time to identify modifications to the sweeping program but will result in more efficient use of staff time.	*Low* Action doesn't address other City goals or objectives.	*Moderate* Debris clogging drain inlet is an issue periodically.	*Moderate* May benefit vulnerable populations if drain inlet clogging is found to be a problem in these areas.	**Moderate**

Resilience Strategy		Effectiveness and Impact	Ease of Implementation	Strategy has Co-benefits	Urgency	Equity	Overall
4	Enhance **data collection and mapping** to fill gaps regarding sensitive areas, hazard areas, and surface water issues	*High* Until more is known about the risk associated locations with missing data, neither high or low score is appropriate.	*Moderate* Many of the data gaps are in areas that are difficult to collect data, making the work more time consuming that typical data collection.	*Moderate* Data collection benefits surface water, critical areas planning, transportation, and general utility planning.	*Moderate* Lack of data on the system creates increasing risk for the City over time.	*Moderate* Neither harms nor benefits vulnerable populations.	**Moderate**
5a	Build **redevelopment-focused regional stormwater facilities**	*Moderate* The of benefits of redevelopment-focused regional facilities are not significantly greater than the benefits of meeting stormwater requirements parcel-by-parcel, though the benefits begin accruing sooner.	*Moderate* Planning, siting, and constructing regional facilities has a high cost, but can be reimbursed (at least partially) through a fee-in-lieu system.	*High* Well planned regional stormwater facilities could improve habitat, recreation, and mobility.	*Moderate* Significant redevelopment around light rail stations and other areas of the city has begun.	*Moderate* Neither harms nor benefits vulnerable populations.	**Moderate**
5b	Build **retrofit-focused regional stormwater facilities**	*High* Retrofit-focused regional facilities have large benefits when compared to business-as-usual approach to stormwater management and flexibility with siting and design to maximize flood reduction and climate resiliency benefits.	*Low* Planning, siting, and constructing regional facilities has a high cost.	*High* Well planned regional stormwater facilities could improve habitat, recreation, and mobility.	*Moderate* As development within the City becomes denser and land values increase, regional stormwater management facilities will become more challenging to site and costly to build.	*High* Has a high potential to integrate equity considerations in facility planning, design, and prioritization.	**High**
6	Require **capital facilities planning** to consider opportunities to increase resiliency using the Climate Impacts Tool	*High* Results in city-wide increases in resilience.	*High* Low level of effort required to consider how each project can increase the City's climate change resilience.	*High* Considering climate change impacts for each project increases the potential for projects to benefit multiple City goals/systems, including stormwater improvements, mobility improvements, reducing impervious surfaces, and improving tree canopy and habitat.	*High* If design standards are not modified, investment in new capital may be built to inadequate standards.	*High* Using the Climate Impacts Tool increases the likelihood that equity is considered on each project.	**High**

Resilience Strategy		Effectiveness and Impact	Ease of Implementation	Strategy has Co-benefits	Urgency	Equity	Overall
7	Proactively plan for increased **staffing for GSI maintenance**	*Moderate* Improved maintenance of City surface water facilities will improve facility performance but the benefit to climate resilience will be limited.	*High* Building staffing needs into surface water rate calculations will enable the utility to adequately staff for the need.	*Moderate* Well maintained GSI facilities will help ensure that the facilities benefit habitat and don't impair mobility or safety.	*Low* The surface water utility is constantly planning for staffing needs.	*Moderate* Neither harms nor benefits vulnerable populations.	**Moderate**
8	Construct **more GSI**	*Moderate* More GSI will help to reduce the impacts of larger storms, but not as much as regional facilities.	*Moderate* Staff are available to implement more GSI and a more detailed review of feasibility criteria and City policy surrounding GSI implementation may result in more GSI being constructed on private and public projects.	*High* More GSI benefits habitat and mobility goals.	*Moderate* Risk that redevelopment that is happening now and in the near future (near light rail stations) occurs in a way that doesn't maximize benefits towards City goals.	*Moderate* Neither harms nor benefits vulnerable populations.	**Moderate**
9	Expand the **Soak-it-Up** program, including enhancing the equity of the program	*Moderate* Residential GSI programs can have significant benefits if implemented broadly but typical GSI facility sizing is not focused on reducing runoff from the most severe storms.	*High* Cost of this program is low when compared to regional stormwater facilities and GSI retrofits.	*Moderate* More residential has numerous benefits, including improved habitat for native species, when properly implemented.	*Low* The window of opportunity for this strategy is long. The benefits of this program are happening now and will increase if more effort is focused on this program.	*Moderate* Neither harms nor benefits vulnerable populations if the program is expanded in a way that increases equity.	**Moderate**
10	Retrofit high-priority **drain inlets** to upgrade capacity	*Moderate* Retrofits at priority (problem) locations could reduce flooding potential at these locations.	*High* Inlet improvements are relatively low cost and do not have significant environmental (permitting) challenges.	*Low* Inlet improvement don't address other City goals and objectives.	*Moderate* Clogged inlets are occasionally problems in some parts of the City.	*Moderate* May benefit vulnerable populations if undersized inlets are found to be a problem in these areas.	**Moderate**
11	Manage **lake eutrophication** through planning, retrofits, and programs	*Low* Expected to result in small impact in resilience, but this rating could be revised depending on the outcome of further planning.	*Moderate* Causes of eutrophication can be difficult to fully assess and eliminate. Further study of this issue would not generally bear a high cost, but cost and effort required to fully manage eutrophication is unknown and may be extensive.	*High* Improving lake water quality has large potential benefits for habitat and recreation.	*Moderate* Poor water quality in lakes has hindered the recreational value of lake and is anticipated to become worse if not addressed.	*Low* Shoreline has only one small lake and the public can access only a small portion of the lake shoreline.	**Low**
12	Evaluate **sea level rise** to develop strategy for managing impacts	*Low* Only a small portion of the City is affected by sea level rise.	*Moderate* GIS data and standardized methodology will make sea level rise assessment a fairly low-effort task, though implementing adaptation actions will likely be high cost.	*Low* Limited benefits to other goals or objectives.	*Moderate* Sea level rise impacts are being experienced now and will continue to become more severe.	*Moderate* Though the private property owners along the marine shoreline are more advantaged, Richmond Beach Park is a major City asset that benefits all people in the City.	**Low**

	Resilience Strategy	Effectiveness and Impact	Ease of Implementation	Strategy has Co-benefits	Urgency	Equity	Overall
Engineering Standards and Design Standards							
13	Develop more robust **downstream analysis requirements**	*High* Would have direct impact on most severe flooding problems in the City on sites that don't already trigger significant onsite flow control.	*High* Will be challenging to manage the additional design review that is required on development projects and some may view this as an unnecessary burden on development.	*Low* Limited benefits besides flood reduction.	*Moderate* Most severe flooding problems can have large impacts every few years; and significant redevelopment around light rail stations has begun.	*Moderate* Addresses flooding impacts that may have disproportionate impacts on the most vulnerable through work being done by the least vulnerable.	**Moderate**
14	Modify design standard for **drain inlets** to increase capacity	*Moderate* Directly addresses a significant contributor to flooding problems in the city (clogged inlets).	*High* Requires limited staff time to develop standards that will be implemented during the normal course of business.	*Low* Limited benefits to other goals or objectives.	*High* Each storm drain inlet that is constructed to an inadequate standard is a missed opportunity.	*High* Flooding of inlets can have disproportionate impacts on vulnerable or marginalized populations.	**High**
15	Modify standards for **stormwater facility sizing** to increase capacity and ensure adequacy of flow control and water quality treatment facilities	*High* Some of the City's most significant flooding problems are a result of undersized facilities.	*High* Low level of effort and low cost to develop and implement standards for City capital projects, particularly those involving conveyance. In the longer-term moderate cost associated with implementing larger stormwater facilities at private developments.	*Moderate* Reduced flooding from undersized conveyance benefits many sectors of the City including transportation, parks, and ecosystems.	*High* Risk that redevelopment that is happening now and in the near future (near light rail stations) occurs in a way that doesn't maximize benefits towards City goals.	*Moderate* Neither harms nor benefits vulnerable populations.	**High**
16	Revise **tree list** and **GSI planting** requirements to be more resilient	*Moderate* Further updates to the City's tree list and GSI planting requirements will improve city-wide climate resilience.	*High* Low level of effort to identify and implement revisions.	*High* Strategy will benefit stormwater, habitat, mobility, and transportation system goals.	*High* The City is making significant right of way improvements in coordination with the new light rail stations so optimizing tree lists and GSI standards present a significant opportunity.	*High* More resilient trees will provide more shade, which will counter urban heat island effects and benefit vulnerable communities.	**High**
17	Modify **urban design standards** to ensure development increases city-wide climate resilience	*Moderate* The City has already completed some updates and additional updates could have significant benefits as redevelopment occurs.	*High* Low level of effort to identify and implement revisions.	*High* Strategy will benefit stormwater, habitat, mobility, and transportation system goals.	*High* The City is making significant right of way improvements in coordination with the new light rail stations so optimizing design standards presents a significant opportunity.	*High* Improved urban design standards will provide more shade, which will counter urban heat island effects and benefit vulnerable communities.	**High**

CRITERIA DEFINITIONS

Effectiveness and Impact	
High	Strategy will result in a large increase in resilience to an important asset or system. Failing to implement this action will risk significant costs/damage to a large portion of the community.
Moderate	Strategy will result in a moderate increase in resilience to an important asset or system.
Low	Strategy will result in a small increase in resilience or only benefit small or less important action. Failing to implement this action will risk minimal costs/damages to the community.

Ease of Implementation	
High	No challenges anticipated given the staff time required to implement this action, cost of external support, and current regulation, politics, and/or technologies.
Moderate	Strategy may encounter challenges given the staff time required to implement this action, cost of external support, and current regulation, politics, and/or technologies.
Low	Strategy will be very challenging given the staff time required to implement this action, cost of external support, and current regulation, politics, and/or technologies.

Strategy has Co-benefits	
High	Strategy addresses multiple high-priority City goals or objectives, in addition to the primary goal that the strategy is focused on.
Moderate	Strategy addresses at least one other high-priority City goals or objectives, in addition to the primary goal that the strategy is focused on.
Low	Strategy doesn't address any other City goals or objectives, besides the primary goal that the strategy is focused on.

Urgency	
High	Window of opportunity for this action is short and/or the cost of inaction will start accruing in a very short time period (less than five years).
Moderate	Window of opportunity for this action is moderate and/or the cost of inaction will start accruing in a moderate time period (five to 10 years).
Low	Window of opportunity for this action is long and/or the cost of inaction won't start accruing for a long time (more than 10 years).

Equity	
High	Strategy will definitely benefit vulnerable/marginalized populations in a significant way.
Moderate	Strategy does not harm nor benefit vulnerable/marginalized populations.
Low	Strategy will negatively affect vulnerable/marginalized populations.

Appendix C.
Resiliency strategies and master plans

APPENDIX C: Comprehensive Review: Opportunities for Advancing Climate Resiliency in the City of Shoreline Master Planning

June 2020

Introduction

The Climate Impacts and Resiliency Study conducted for the City of Shoreline identified a set of seventeen strategies to increase climate resiliency. The consultant team carried out a comprehensive review of existing City master plans to identify opportunities to advance the resilience strategies in the next round of master plan updates, as well as increase climate resiliency in projects and operations across all City departments.

The scope of the Climate Impacts and Resiliency Study focused on resilience strategies specifically for the stormwater system, in part due to expected climate impacts leading to more intense rainstorms and greater flooding risk. However, these strategies also build resilience in other systems (e.g., transportation, wastewater, parks). There are many potential strategies less directly related to the stormwater system that can also contribute to climate resilience (e.g., creating cooling centers to provide relief from extreme heat); future City planning efforts to build holistic, citywide climate resilience could identify, develop, and integrate these types of strategies into City master plans as well.

The City provided the list of master plans for the consultant to include in this review, listed below with hyperlinks to the online documents, when available. The acronyms correspond to columns in Table 1, which provides a high-level summary of the seventeen climate resilience strategies and the master plans they most closely pertain to.

- Comprehensive Plan (COMP)
- Climate Action Plan (CAP)
- Economic Development Strategy (EDS)
- Parks, Recreation, and Open Space Plan (PROS)
- Ronald Wastewater District Comprehensive Plan (RWDCP)
- Surface Water Master Plan (SWMP)
- Transportation Master Plan (TMP)

Table 1. Summary table of climate resilience strategies and alignment with City master plans. Strategies in bold font are high-priority strategies based on a prioritization process conducted during the Climate Impacts and Resiliency Study.

CLIMATE RESILIENCE STRATEGY	MASTER PLAN						
	COMP	CAP	EDS	PROS	RWDCP	SWMP	TMP
1. Hazards	●						
2. Partnership	●	●	●	●		●	●
3. Street Sweeping						●	
4. Data Collection	●		●	●	●	●	●
5. Regional Stormwater Facilities	●					●	
6. Capital Facilities Planning	●	●	●	●	●	●	●
7. Proactive Maintenance Staffing						●	●
8. More Green Stormwater Infrastructure	●	●	●	●	●	●	●
9. Soak-it-Up Rebate Program	●		●			●	
10. Retrofit Drain Inlets	●					●	
11. Manage Lake Eutrophication	●					●	
12. Evaluate Sea Level Rise	●				●	●	●
13. More Robust Downstream Analysis Requirements						●	
14. Drain Inlets						●	
15. Stormwater Facility Sizing						●	
16. Resilient Planting	●	●	●	●		●	●
17. More Resilient Urban Design Standards	●	●	●	●	●	●	●

The following sections, organized by master plan, identify the applicable resilience strategies for each plan and the corresponding plan component(s) where opportunities exist to advance the respective strategies. When appropriate, specific sub-section(s) were identified; otherwise, "All" is utilized to indicate that the strategy applies to the entire plan component and/or there was not a specific sub-section that was any more relevant than the others. The aim of this format is to provide a simple resource for planning managers to easily incorporate these strategies into the next planning updates.

For more information, please contact Autumn Salamack or John Featherstone.

Comprehensive Plan

Current plan period: 2012-2023

Scheduled update: June 2023

Lead Department/Staff: Planning & Community Development, Planning Manager and/or Senior Planner

Climate Resilience Strategy	Comprehensive Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #1 – Hazards: Evaluate the development code related to landslide hazards to reduce risk. This action should be preceded by a detailed assessment and improved mapping of hazard areas (see Strategy #4 - Data Collection).	Natural Environment	Geological and Flood Hazard Areas
Strategy #2 – Partnership: Develop a framework for public and private partnerships that work towards a more resilient city through stormwater management strategies that increase green space, habitat connections, and mobility. Examples might include: • Green space management planning and permitting to streamline the City permitting process and facilitate climate-resilient best management practices for privately-owned and managed green spaces. • Opportunities for stormwater system easements to create habitat networks or to connect ecosystem services. • Opportunities to leverage green stormwater infrastructure (GSI) to expand and connect pedestrian/bicycle path networks for alternative transportation routes, including connections to the Interurban Trail.	Land Use	Water Quality and Drainage (LU69)
	Community Design	Site and Building Design (CD3) Sidewalks, Walkways and Trails
	Transportation	Sustainability and Quality of Life (T10)
	Economic Development	Quality of Life
	Parks, Recreation & Open Space	Policy 4.4
Strategy #4 – Data Collection: Implement proactive data collection and mapping of stormwater system components and critical areas to improve the City's ability to evaluate stormwater system deficiencies, improve system resilience, and protect critical areas (streams, wetlands, and geologic hazard areas). Improved hazard mapping (especially for slide areas) is recommended because seasonal changes in rainfall could impact the sensitivity of slide-prone areas.	Natural Environment	Geological and Flood Hazard Areas
Strategy #5 – Regional Stormwater Facilities: Plan and construct regional stormwater facilities to protect surface water bodies by providing flow control and/or water quality treatment. The City can take two primary approaches to regional stormwater facilities: • Redevelopment-focused regional stormwater facilities, i.e. those that are located downstream of areas that are expected to experience significant redevelopment. • Retrofit-focused regional stormwater facilities, i.e. those that are focused toward providing the maximum stormwater benefits downstream of developed areas, regardless of whether the tributary area is likely to experience significant redevelopment.	Land Use	Water Quality and Drainage (LU69)
	Natural Environment	Geological and Flood Hazard Areas

Climate Resilience Strategy	Comprehensive Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #6 – Capital Facilities Planning: Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool. This should be documented in the upcoming Project Management Manual. As more information becomes available on stormwater system capacity and flooding problems, add this information to the Climate Impacts Tool.	Land Use	Water Quality and Drainage (LU69)
	Housing	All
	Transportation	Master Street Plan
	Economic Development	Quality of Life
	Natural Environment	Geological and Flood Hazard Areas Sustainability (NE44)
	Parks, Recreation & Open Space	Policy 3.3
	Capital Facilities	Mitigation and Efficiency (CF15)
	Utilities	Mitigation and Efficiency (U6)
Strategy #8 – More GSI: Construct more GSI through retrofit programs or policies to include GSI on City projects. Retrofit planning for GSI could include identifying priority areas based on downstream system capacity limitations and aquatic resource prioritization. Continue to evaluate and modify codes and/or standards to make GSI the preferred choice for development. Target grant applications to support projects that plan and implement GSI retrofits. If possible, coordinate with sidewalk, bike lane, and other mobility improvements in the ROW. Develop GSI Design Standards, such as standard plans, details, and specifications with a focus on consistency, function, and consideration of climate impacts.	Land Use	Water Quality and Drainage (LU69)
	Community Design	Street Corridors (CD32) Residential (CD36)
	Natural Environment	Geological and Flood Hazard Areas Sustainability (NE45)
	Parks, Recreation & Open Space	Policy 1.1
	Capital Facilities	Mitigation and Efficiency (CF16)
Strategy #9 – Soak-it-Up Rebate Program: Expand the Soak-it-Up program to further incentivize construction of GSI facilities. Improve the program to be more equitable, potentially through grants, targeted outreach and education, and actions that can benefit disadvantaged, including approaches that benefit individuals that don't own property.	Land Use	Water Quality and Drainage (LU69)
	Natural Environment	Geological and Flood Hazard Areas
Strategy #10 – Retrofit Drain Inlets: Identify high-priority inlets and implement a retrofit program to upgrade inlets for improved capacity. Consider equity issues when identifying the high-priority inlets.	Natural Environment	Geological and Flood Hazard Areas
Strategy #11 – Manage Lake Eutrophication: Rising temperatures may exacerbate water quality challenges associated with lakes. Evaluate the causes of lake eutrophication and proactively develop and implement lake management plans to include additional upstream stormwater requirements, stormwater retrofits, and/or in-lake remediation activities, depending on the identified causes.	Natural Environment	Streams and Water Resources
Strategy #12 – Evaluate Sea Level Rise: Evaluate sea level rise in greater detail and develop strategy to address potential impacts to surface water outfalls, City property and park facilities, and private property.	Shoreline Master Program	All

Climate Resilience Strategy	Comprehensive Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #16 – Resilient Planting: Revise tree list and GSI planting requirements to create more resilient urban habitat and expand urban forest canopy. Based on a high-level review of the current tree list, preliminary suggestions include the following.	Community Design	Vegetation and Landscaping
	Transportation	Sustainability and Quality of Life
	Natural Environment	Vegetation Protection
	Parks, Recreation & Open Space	Policy 1.1
Strategy #17 – More Resilient Urban Design Standards: Consider modifying design standards to ensure that future development increases city-wide resilience to climate change. As an example, modify design standards to encourage more vegetation and large trees. In addition to stormwater benefits, vegetation can improve urban habitat and provide shading to mitigate urban heat island effects.	Land Use	All
	Community Design	All
	Transportation	Master Street Plan

Climate Action Plan

Current plan period: 2013-present

Scheduled update: 2021-2022

Lead Department/Staff: Community Services, Environmental Services Coordinator

Climate Resilience Strategy	Climate Action Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #2 – Partnership: Develop a framework for public and private partnerships that work towards a more resilient city through stormwater management strategies that increase green space, habitat connections, and mobility. For example, partnerships could support opportunities to leverage green stormwater infrastructure (GSI) to expand and connect pedestrian/bicycle path networks for alternative transportation routes, including connections to the Interurban Trail.	Transportation, Land Use, and Mobility	**Objective 8:** Alternative Transportation
	Urban Trees, Parks, and Open Spaces	**Objective 11:** Parks & Open Spaces
Strategy #6 – Capital Facilities Planning: Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool. This should be documented in the upcoming Project Management Manual. As more information becomes available on stormwater system capacity and flooding problems, add this information to the Climate Impacts Tool.	Energy and Water	All
	Materials and Waste	All
	Transportation, Land Use, and Mobility	All
	Urban Trees, Parks, and Open Spaces	All
Strategy #8 – More GSI: Construct more GSI through retrofit programs or policies to include GSI on City projects. Retrofit planning for GSI could include identifying priority areas based on downstream system capacity limitations and aquatic resource prioritization. Continue to evaluate and modify codes and/or standards to make GSI the preferred choice for development. Target grant applications to support projects that plan and implement GSI retrofits. If possible, coordinate with sidewalk, bike lane, and other mobility improvements in the ROW. Develop GSI Design Standards, such as standard plans, details, and specifications with a focus on consistency, function, and consideration of climate impacts.	Transportation, Land Use, and Mobility	**Objective 8:** Alternative Transportation
	Urban Trees, Parks, and Open Spaces	**Objective 11:** Parks & Open Spaces
Strategy #16 – Resilient Planting: Revise tree list and GSI planting requirements to create more resilient urban habitat and expand urban forest canopy. Co-benefits include more resilient urban habitat, expanded urban forest canopy, reduced urban heat island effect, and greenhouse gas emissions mitigation.	Energy and Water	**Objective 3:** Water Consumption
	Transportation, Land Use, and Mobility	**Objective 8:** Alternative Transportation
	Urban Trees, Parks, and Open Spaces	**Objective 10:** Tree Canopy & Health **Objective 11:** Parks & Open Spaces
Strategy #17 – More Resilient Urban Design Standards: Consider modifying design standards to ensure that future development increases city-wide resilience to climate change. As an example, modify design standards to encourage more vegetation and large trees. In addition to stormwater benefits, vegetation can improve urban habitat and provide shading to mitigate urban heat island effects.	Transportation, Land Use, and Mobility	**Objective 8:** Alternative Transportation

Economic Development Strategy

Current plan period: 2018-2023

Scheduled update: December 2023

Lead Department/Staff: Not specified in the Comprehensive and Master Plan Update Memo, August 15, 2019.

Climate Resilience Strategy	Economic Development Strategy Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #2 – Partnership: Develop a framework for public and private partnerships that work towards a more resilient city through stormwater management strategies that increase green space, habitat connections, and mobility. For example, streamlining the City permitting process could facilitate climate-resilient best management practices for privately-owned and managed green spaces.	City-Shaping Areas	All
	Neighborhood Commercial Centers	All
	Non-geographic Placemaking Projects	**Facilitating Collaboration** With & Between Businesses
Strategy #4 – Data Collection: Use the inventory to implement proactive data collection of critical areas that experience erosion and/or flooding to inform improved mapping and evaluation of the City's stormwater system. Also collect data about vulnerability to urban heat islands within business centers to evaluate areas with opportunity for building resilience.	Non-geographic Placemaking Projects	**Increasing Inventory** of Business Spaces
Strategy #6 – Capital Facilities Planning: Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool. This should be documented in the upcoming Project Management Manual.	City-Shaping Areas	All
	Neighborhood Commercial Centers	All
Strategy #8 – More Green Stormwater Infrastructure (GSI): Construct more GSI through retrofit programs or policies to include GSI on City projects. Continue to evaluate and modify codes and/or standards to make GSI the preferred choice for development. Target grant applications to support projects that plan and implement GSI retrofits. If possible, coordinate with sidewalk, bike lane, and other mobility improvements in the ROW. Develop GSI Design Standards, such as standard plans, details, and specifications with a focus on consistency, function, and consideration of climate impacts.	City-Shaping Areas	All; especially **Shoreline Place**
	Neighborhood Commercial Centers	All; especially **North City Business District** & **Downtown Ridgecrest**
Strategy #9 – Soak-it-Up Rebate Program: Expand the Soak-it-Up program to further incentivize construction of GSI facilities. Improve the program to be more equitable, potentially through grants, targeted outreach and education, and actions that can benefit disadvantaged, including approaches that benefit individuals that don't own property.	City-Shaping Areas	All
	Neighborhood Commercial Centers	All
	Non-geographic Placemaking Projects	**Facilitating Collaboration** With & Between Businesses
Strategy #16 – Resilient Planting: Create a safer and more enjoyable urban environment by increasing tree plantings and planting tree species that will be more resilient to climate impacts, particularly in priority	City-Shaping Areas	All; especially **Shoreline's Signature Boulevard** & **Shoreline Place**

Climate Resilience Strategy	Economic Development Strategy Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
development areas. Co-benefits include more resilient urban habitat, expanded urban forest canopy, reduced urban heat island effect, and greenhouse gas emissions mitigation.	Neighborhood Commercial Centers	All; especially **Shoreline Town Center** & **Ballinger Commercial Center**
Strategy #17 – More Resilient Urban Design Standards: Consider modifying design standards to ensure that future development increases city-wide resilience to climate change, especially for new developments and redevelopment. As an example, modify design standards to encourage more vegetation and large trees. In addition to stormwater benefits, vegetation can improve urban habitat and provide shading to mitigate urban heat island effects.	Non-geographic Placemaking Projects	Continually Improving **Code & Policies**

Parks, Recreation, and Open Space Plan

Current plan period: 2017-2023

Scheduled update: December 2023

Lead Department/Staff: PRCS, Director or designee

Climate Resilience Strategy	PROS Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #2 – Partnership: Develop a framework for public and private partnerships that work towards a more resilient city through stormwater management strategies that increase green space, habitat connections, and mobility. For example, partnerships could support opportunities to leverage green stormwater infrastructure (GSI) to expand and connect pedestrian/bicycle path networks for alternative transportation routes, including connections to the Interurban Trail.	Recommendations & Implementation	**Initiative 9:** Improve walkability
Strategy #4 – Data Collection: Implement proactive data collection of critical areas that experience erosion and/or flooding to inform improved mapping and evaluation of the City's stormwater system. Use the inventory to also collect data about vulnerability to urban heat islands within the parks, recreation, and open space system and evaluate areas with opportunity for building resilience.	Community Profile	All
Strategy #6 – Capital Facilities Planning: Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool. This should be documented in the upcoming Project Management Manual.	Community Profile	All
	Demand & Needs Assessment	**Goal 1:** Preserve/enhance natural facilities
	Recommendations & Implementation	**Initiative 1:** New aquatic center **Initiative 3:** Expand amenities **Initiative 9:** Improve walkability **Prioritization criteria**
Strategy #8 – More Green Stormwater Infrastructure (GSI): Construct more GSI through retrofit programs or policies to include GSI on City projects. Continue to evaluate and modify codes and/or standards to make GSI the preferred choice for development. Target grant applications to support projects that plan and implement GSI retrofits. If possible, coordinate with sidewalk, bike lane, and other mobility improvements in the ROW. Develop GSI Design Standards, such as standard plans, details, and specifications with a focus on consistency, function, and consideration of climate impacts.	Recommendations & Implementation	**Initiative 1:** New aquatic center **Initiative 3:** Expand amenities
Strategy #16 – Resilient Planting: Create a safer and more enjoyable biking, walking, and transit experience by increasing tree plantings and planting tree species that will be more resilient to climate impacts. Co-	Facilities, Services & Programs	Park maintenance & urban forestry*

Climate Resilience Strategy	PROS Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
benefits include more resilient urban habitat, expanded urban forest canopy, reduced urban heat island effect, and greenhouse gas emissions mitigation.	Recommendations & Implementation	**Initiative 8:** Urban forest
Strategy #17 – More Resilient Urban Design Standards: Consider modifying design standards for the transportation system to ensure that future development increases city-wide resilience to climate change.	Vision, Goals & Policies	**Goal 1:** Preserve/enhance natural facilities

*Note: There is no specific initiative or goal associated with the Park maintenance and urban forestry sub-section in the PROS Plan.

Ronald Wastewater District Comprehensive Plan

Current plan period: 2010-present

Scheduled update: 2021/2022

Lead Department/Staff: Public Works, Utility & Operations Manager

Climate Resilience Strategy	Ronald Wastewater District Comp. Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #4 – Data Collection: Implement proactive data collection of critical areas that experience erosion and/or flooding to inform improved mapping and evaluation of the City's stormwater system. Use the inventory to also collect data about vulnerability to urban heat islands within the wastewater system and evaluate areas with opportunity for building resilience.	Existing Sewer System	All
Strategy #6 – Capital Facilities Planning: Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool. This should be documented in the upcoming Project Management Manual. Use the tool to assess the physical characteristics of the entire wastewater system as well.	Physical and Economic Considerations	All
	Capital Facilities Plan	All
Strategy #8 – More Green Stormwater Infrastructure (GSI): Construct more GSI through retrofit programs or policies to include GSI on City projects, specifically identifying opportunities to incorporate GSI in wastewater system improvements. Continue to evaluate and modify codes and/or standards to make GSI the preferred choice for development. Target grant applications to support projects that plan and implement GSI retrofits. If possible, coordinate with sidewalk, bike lane, and other mobility improvements in the ROW. Develop GSI Design Standards, such as standard plans, details, and specifications with a focus on consistency, function, and consideration of climate impacts.	Capital Facilities Plan	All
Strategy #12 – Evaluate Sea Level Rise: Evaluate sea level rise in greater detail and develop strategy to address potential impacts to the wastewater system and City property.	Physical and Economic Considerations	All
Strategy #17 – More Resilient Urban Design Standards: Consider modifying design standards to ensure that future development increases city-wide resilience to climate change, especially for new developments and redevelopment.	Design Criteria	All

Surface Water Master Plan

Current plan period: 2018-2023

Scheduled update: December 2023 (to inform 2025/2026 budget, due June 2024)

Lead Department/Staff: Public Works, Surface Water Utility Manager

Climate Resilience Strategy	Surface Water Master Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #2 – Partnership: Develop a framework for public and private partnerships that work towards a more resilient city through stormwater management strategies that increase green space, habitat connections, and mobility. Examples might include: • Green space management planning and permitting to streamline the City permitting process and facilitate climate-resilient best management practices for privately-owned and managed green spaces. • Opportunities for stormwater system easements to create habitat networks or to connect ecosystem services. • Opportunities to leverage green stormwater infrastructure (GSI) to expand and connect pedestrian/bicycle path networks for alternative transportation routes, including connections to the Interurban Trail.	Policies and Procedures	**6** Policies and Procedures
	Utility Programs	**7.3** Public Involvement Programs
Strategy #3 – Street Sweeping: Evaluate the street sweeping program to identify changes to sweeping locations, timing, and frequency that could increase resilience to climate change and equity, particularly reducing the likelihood that drain inlets clog during large storms and the potential to improve water quality in surface water bodies in the city, and potential benefit to benefit vulnerable populations. Expand or modify the street sweeping program based on the findings. Note that efforts to expand the urban forest canopy may contribute additional leaf litter that could clog storm drain inlets.	Utility Programs	**7.2.1** Street Sweeping
Strategy #4 – Data Collection: Implement proactive data collection and mapping of stormwater system components and critical areas to improve the City's ability to evaluate stormwater system deficiencies, improve system resilience, and protect critical areas (streams, wetlands, and geologic hazard areas). Improved hazard mapping (especially for slide areas) is recommended because seasonal changes in rainfall could impact the sensitivity of slide-prone areas.	Systems Evaluation	**4.2** Conveyance Capacity
	Utility Programs	**7.1.6** Asset Management
Strategy #5 – Regional Stormwater Facilities: Plan and construct regional stormwater facilities to protect surface water bodies by providing flow control and/or water quality treatment. The City can take two primary approaches to regional stormwater facilities:	Policies and Procedures	**6** Policies and Procedures

Climate Resilience Strategy	Surface Water Master Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
a. Redevelopment-focused regional stormwater facilities, i.e. those that are located downstream of areas that are expected to experience significant redevelopment. b. Retrofit-focused regional stormwater facilities, i.e. those that are focused toward providing the maximum stormwater benefits downstream of developed areas, regardless of whether the tributary area is likely to experience significant redevelopment.	Implementation	**10.3** Projects
Strategy #6 – Capital Facilities Planning: Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool. This should be documented in the upcoming Public Works' Project Management Manual. As more information becomes available on stormwater system capacity and flooding problems, add this information to the Climate Impacts Tool.	Levels of Service	**2.2** Defining Levels of Service
	Drainage Systems	All
	Utility Programs	**7.1.4** Drainage Assessment
	Management Strategies	**8.1** Prioritization Process
	Implementation	**10.3** Projects
Strategy #7 – Proactive Maintenance Staffing: Forecast City GSI installations to anticipate maintenance personnel shortages in the future, because GSI requires specialized maintenance and can be maintenance intensive. Incorporate any necessary increases in staffing into the next Surface Water Master Plan update and surface water utility rate assessment.	Levels of Service	**2.2** Defining Levels of Service
	Policies and Procedures	**6** Policies and Procedures
	Utility Programs	**7.2.7** Low Impact Development Maintenance
	Implementation	**10.2.1** Staffing Needs
Strategy #8 – More GSI: Construct more GSI through retrofit programs or policies to include GSI on City projects. Retrofit planning for GSI could include identifying priority areas based on downstream system capacity limitations and aquatic resource prioritization. Continue to evaluate and modify codes and/or standards to make GSI the preferred choice for development. Target grant applications to support projects that plan and implement GSI retrofits. If possible, coordinate with sidewalk, bike lane, and other mobility improvements in the ROW. Develop GSI Design Standards, such as standard plans, details, and specifications with a focus on consistency, function, and consideration of climate impacts.	Systems Evaluation	**4.3** Water Quality
	Policies and Procedures	**6.2.2** Engineering Development Manual
	Implementation	**10.3** Projects
Strategy #9 – Soak-it-Up Rebate Program: Expand the Soak-it-Up program to further incentivize construction of GSI facilities. Improve the program to be more equitable, potentially through grants, targeted outreach and education, and actions that can benefit disadvantaged, including approaches that benefit individuals that don't own property.	Utility Programs	**7.3.1** Soak It Up Low Impact Development Rebate
	Implementation	**10.3** Projects
Strategy #10 – Retrofit Drain Inlets: Identify high-priority inlets and implement a retrofit program to upgrade inlets for improved capacity. Consider equity issues when identifying the high-priority inlets.	Utility Programs	**7.1.4** Drainage Assessment
	Implementation	**10.3** Projects

Climate Resilience Strategy	Surface Water Master Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #11 – Manage Lake Eutrophication: Rising temperatures may exacerbate water quality challenges associated with lakes. Evaluate the causes of lake eutrophication and proactively develop and implement lake management plans to include additional upstream stormwater requirements, stormwater retrofits, and/or in-lake remediation activities, depending on the identified causes.	Drainage Systems	All
	Systems Evaluation	**4.3** Water Quality
Strategy #12 – Evaluate Sea Level Rise: Evaluate sea level rise in greater detail and develop strategy to address potential impacts to surface water outfalls, City property and park facilities, and private property.	Systems Evaluation	**4.2** Conveyance Capacity
Strategy #13 – More Robust Downstream Analysis Requirements: Develop more robust requirements for downstream analysis, including identification of existing stormwater problem areas. For example, Chapter 1 of the King County Surface Water Design Manual (KCSWDM) includes a section on Downstream Drainage Problems Requiring Special Attention. The KCSWDM lists four problem categories: (1) conveyance system nuisance, (2) severe erosion, (3) severe flooding, (4) potential impacts to wetland hydrology. The City could develop and adopt similar requirements to trigger special stormwater mitigation in places where existing problems are most severe.	Systems Evaluation	**4.2** Conveyance Capacity
	Policies and Procedures	**6.2.2** Engineering Development Manual
Strategy #14 – Drain Inlets: Modify design standard to require combination inlets or dual inlets under certain conditions (e.g., sags in the roadway, areas with history of clogging or capacity-related flooding, areas with significant tree canopy) to increase capacity for higher-intensity storm events and reduce the risk of clogging. Increased inlet capacity may result in additional debris in the downstream pipe network, which can be partially offset by preventative programs such as street sweeping.	Systems Evaluation	**4.2** Conveyance Capacity
	Policies and Procedures	**6.2.2** Engineering Development Manual
Strategy #15 – Stormwater Facility Sizing: Modify the standards for design of conveyance, flow control, and treatment facilities. Examples are given below. • **Conveyance:** Require application of a climate change safety factor on design flows used in conveyance sizing (near term). • **Flow control and treatment facilities:** Require analysis using a precipitation timeseries that has been modified to account for climate change impacts after a regionally accepted standard of practice has been defined (longer term).	Systems Evaluation	**4.2** Conveyance Capacity
	Policies and Procedures	**6.2.2** Engineering Development Manual
Strategy #16 – Resilient Planting: Revise tree list and GSI planting requirements to create more resilient urban habitat and expand urban forest canopy. Based on a high-level review of the current tree list, preliminary suggestions include the following.	Policies and Procedures	**6.2.5** City of Shoreline Comprehensive Plan

Climate Resilience Strategy	Surface Water Master Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #17 – More Resilient Urban Design Standards: Consider modifying design standards to ensure that future development increases city-wide resilience to climate change. As an example, modify design standards to encourage more vegetation and large trees. In addition to stormwater benefits, vegetation can improve urban habitat and provide shading to mitigate urban heat island effects.	Policies and Procedures	**6.2.5** City of Shoreline Comprehensive Plan

Transportation Master Plan

Current plan period: 2011-2021

Scheduled update: December 2022

Lead Department/Staff: Public Works, Transportation Division

Climate Resilience Strategy	Transportation Master Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
Strategy #2 – Partnership: Develop a framework for public and private partnerships that work towards a more resilient city through stormwater management strategies that increase green space, habitat connections, and mobility. For example, partnerships could support opportunities to leverage green stormwater infrastructure (GSI) to expand and connect pedestrian/bicycle path networks for alternative transportation routes, including connections to the Interurban Trail.	Bicycle Plan	System Continuity
	Pedestrian Plan	System Continuity
Strategy #4 – Data Collection: Collect data on areas in the transportation system that experience erosion and/or flooding to inform improved mapping and evaluation of the City's stormwater system. Use the inventory to also collect data about vulnerability to urban heat islands within the transportation system and evaluate areas with opportunity for building resilience.	Inventory	All
Strategy #6 – Capital Facilities Planning: Require capital project managers to review near-term planned and proposed projects for their potential to improve surface water issues, reduce urban heat island effects, and/or increase equitable services by using the Climate Impacts Tool.	Inventory	All
	Pedestrian Plan	Prioritization – Equity
Strategy #7 – Proactive Maintenance Staffing: Forecast GSI installations within the transportation system to anticipate maintenance personnel shortages in the future. Incorporate any necessary increases in staffing into the next Transportation Master Plan update.	Sustainability & Quality of Life	Maintenance
Strategy #8 – More Green Stormwater Infrastructure (GSI): Inventory current GSI installations within the transportation system (if such an inventory does not already exist) and specifically flag locations where GSI provides co-benefits, such as increasing connectivity of pedestrian and bike networks. Construct more GSI through retrofit programs or policies to include GSI on City projects. Coordinate GSI with sidewalk, bike lane, and other mobility improvements in the ROW.	Inventory	All
Strategy #12 – Evaluate Sea Level Rise (SLR): Assess SLR impacts to the transportation system.	Inventory	All
Strategy #16 – Resilient Planting: Create a safer and more enjoyable biking, walking, and transit experience by increasing tree plantings and planting tree species that will be more resilient to climate impacts. Co-	Sustainability & Quality of Life	All

Climate Resilience Strategy	Transportation Master Plan Section(s) Most Aligned with Strategy	
	PLAN COMPONENT	SUB-SECTION
benefits include more resilient urban habitat, expanded urban forest canopy, reduced urban heat island effect, and greenhouse gas emissions mitigation	Bicycle Plan	Safety and Quality
	Pedestrian Plan	Safety and Quality
	Transit Plan	Improving Key Passenger Facilities
Strategy #17 – More Resilient Urban Design Standards: Consider modifying design standards for the transportation system to ensure that future development increases city-wide resilience to climate change.	Sustainability & Quality of Life	All
	Bicycle Plan	Safety and Quality
	Pedestrian Plan	Safety and Quality

SUMMARY MEMO | November 21, 2019

Observed Trends and Projected Climate Change Impacts for the City of Shoreline

INTRODUCTION

This document provides an overview of observed and projected climate changes in the Puget Sound region. A team of consultants from Cascadia Consulting Group and Herrera developed this summary document for the City of Shoreline's Climate Impacts and Resiliency Study.

This summary is intended to provide the City of Shoreline with a foundation to understand and plan for anticipated climate impacts to municipal assets, operations, and services. The document focuses on the main regional *drivers* of climate change impacts (e.g., changes in precipitation patterns) rather than the full spectrum of resulting *impacts* (e.g., wildfire, landslides); resulting impacts are considered in separate vulnerability assessments specific to the surface water system, built environment, critical areas and ecosystems, and public health and safety.

This document provides the latest available climate science information from academic literature, research organizations, and institutions. Key sources of information consulted for this memo include the following:

- ***State of Knowledge: Climate Change in Puget Sound***, prepared by University of Washington Climate Impacts Group (CIG), 2015.
- ***Fifth National Climate Assessment Synthesis Report***, Intergovernmental Panel on Climate Change, 2014.
- ***Projected Sea Level Rise for Washington State***, prepared by Washington Sea Grant, CIG, University of Oregon, University of Washington, and US Geological Survey, 2018.
- ***New Projections of Changing Heavy Precipitation in King County***, prepared by CIG, 2018.
- ***Implications of 21st century climate change for the hydrology of Washington State***, by Elsner *et al.* 2010.

This document begins with a brief overview of the science, methods, and geographic scales of climate change projections and their application to decision-making. It then presents the observed trends and projected changes in climate for temperature, precipitation and local flooding, Puget Sound hydrology, and sea level rise and storm surge. In each of these sections, blue boxes highlight key findings, followed by more detailed and technical information. The document concludes with a table summarizing key findings from the blue boxes.

Table of Contents

CLIMATE CHANGE OVERVIEW

Projecting Future Climate

- **Climate projections are based on possible scenarios for how the global population may generate greenhouse gas (GHG) emissions in the future.** These scenarios are called Representative Concentration Pathways (RCPs).
- **Recent observed GHG emissions have aligned more closely with the higher emissions scenarios**, yet all scenarios are possible.

Understanding how human-caused emissions of greenhouse gases (GHGs) are likely to affect our global climate requires the use of complex climate models. These models consider many factors—such as technology advancements, population growth, economic development, energy generation methodologies, and land use approaches—that influence global GHG emissions. So that climate studies remain consistent and comparable, researchers use a standard set of modeled GHG emissions scenarios when determining the possible climate impacts of emissions.

The International Panel on Climate Change (IPCC) has published three different iterations of these climate change scenarios as scientific understanding and computing capabilities have progressed. The newest set of scenarios, developed in 2013, consists of four commonly used Representative Concentration Pathways (RCPs): RCP 8.5, RCP 6.0, RCP 4.5, and RCP 2.6 (see Table 1 and Figure 1).[1]

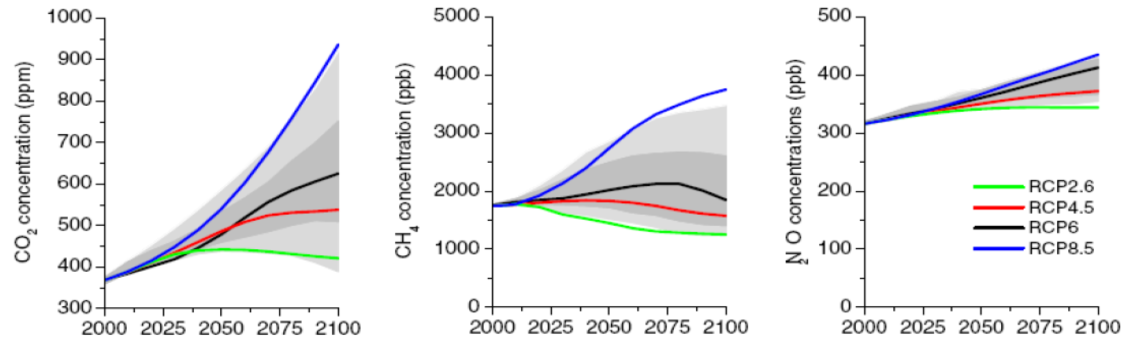
Table 1. Description of RCPs. The IPCC facilitated the development of the scenarios represented in this table. The rankings (e.g., "High," "Low") are based on the scenario's projection of global GHG emissions levels in 2100.[2]

RCP	Description
RCP 8.5	***High GHG emissions scenario:*** Assumes that global GHG emissions increase over time, with high population growth, lower gross domestic product (GDP), and high coal and oil consumption. By 2100, carbon dioxide concentration reaches 1,370 ppm.
RCP 6.0	***Moderate GHG emissions scenario***: Assumes global emissions stabilize shortly after 2100 through a range of GHG emissions reduction technologies and strategies. Assumes moderate population growth, and low GDP, lower energy (primarily from natural gas and oil) and moderate oil consumption. By 2100, carbon dioxide concentration reaches 850 ppm.
RCP 4.5	***Low GHG emissions scenario:*** Assumes global emissions stabilize at a specific level shortly after 2100. Assumes low population growth, moderate GDP, and lower energy (primarily from bio-energy, natural gas, coal, and oil) and moderate oil consumption. By 2100, carbon dioxide concentration reaches 650 ppm.
RCP 2.6	***Very low GHG emissions scenario:*** Assumes global emissions peak and then decline significantly over time, with low population growth, high GDP, and lower energy (primarily from coal and bio-energy) and oil consumption. By 2100, carbon dioxide concentration reaches 490 ppm.

[1] The RCPs replace the scenarios used in IPCC's previous assessments known as the Special Report on Emissions Scenarios (SRES). More information on the RCPs and how they relate to the SRES can be found in Box 2.2 of the IPCC Fourth Climate Change Assessment Synthesis Report.

[2] Riahi *et al.* 2007; Van Vuuren *et al*. 2011; Moss *et al.* 2010; Rogelj *et al.* 2012

Figure 1. GHG concentrations by RCP and GHG type—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). [3]



It is difficult to verify which model most accurately matches future conditions. However, it is worth noting that **observed increases in GHG emissions over the past 15 to 20 years align most closely with those projected in the higher emission scenarios, such as RCPs 6.0 and 8.5**.[4]

The IPCC's 2018 report urges cities and countries to take rapid action to keep global warming below 1.5°C in the 21st century [1]. The latest IPCC global climate change synthesis report indicates that RCP 2.6 is the only pathway that is likely to keep global warming below 2°C. It depends on substantial net negative emissions, meaning that carbon must be removed from the atmosphere (see Table 2) [2].

It can be useful to aim for a low emissions trajectory like RCP 2.6 when setting GHG emissions reduction targets and planning mitigation strategies. However, when preparing for climate change impacts and planning resilience strategies, it is important to prepare for the more severe conditions projected in high emissions scenarios, which are unlikely to limit warming to 2°C. I**n this report we use RCPs 4.5 and 8.5 to provide a low and high bracketed projection for future emissions, which is aligned with common practices in national and regional climate projection reports.**

Table 2. Likelihood of future emissions scenarios to keep global warming in the 21st century below given temperature thresholds. Adapted from Table 3.1 in IPCC Synthesis Report (2014).

RCPs	Likelihood of staying below a specific global temperature level over the 21st century (relative to 1850-1900)			
	1.5°C	2°C	3°C	4°C
RCP 2.6	<50%		>65%	
RCP 4.5		<50%	>50%	
RCP 6.0			<50%	
RCP 8.5	<33%			<50%

Geographic Scale

Global climate models used to generate projections of future climate impacts simulate changes at broad geographic scales or resolutions, with about 50 to 100 miles between one "pixel" or grid cell to the next. At this scale, the projections are not representative of local-scale patterns in weather and climate. "Downscaling" refers to taking the coarse resolution projections from global climate models and applying them to a smaller geographic scale, achieving a level of detail that is more relevant to local management and

[3] Chart reproduced from Van Vuuren *et al*. 2011.

[4] Hayhoe *et al.* 2017

decision-making. The increased resolution from downscaling is usually about 5 to 10 miles from one grid cell to the next; this is a 10-fold increase compared to global climate models. However, climate modeling results generally become less accurate at a smaller geographic scale, especially at the sub-regional level. Downscaling is also costly. As a result, it is uncommon to have climate projections at the city or county level.

In this report, we most often use downscaled projections for the Puget Sound region (see Figure 2) created by the University of Washington's Climate Impacts Group (CIG). We also use some projections for Washington State or the Pacific Northwest more broadly to provide context and confirm the accuracy of downscaled projections. We use downscaled projections at the sub-regional level (King County, Seattle, and Shoreline) for changes in heavy precipitation and sea level rise. Sub-regional downscaled projections were not available for temperature and hydrology changes.

Figure 2. Boundary of the Puget Sound region used for many downscaled projections in this report. The red dot indicates Shoreline's approximate location. **[4]**

Climate Variability

The Puget Sound region's climate is complex and diverse, with natural variability. Climate variability refers to the changes in climate that range over many time and space scales. Climate variability in the Puget Sound region is partially due to the year-to-year and decade-to-decade Pacific Ocean trends. These include the El Niño-Southern Oscillation (ENSO), also known as El Niño/La Niña and the Pacific Decadal Oscillation (PDO) [3]. These patterns affect ocean and air temperatures, local winds, and precipitation. They affect the Puget Sound region by generating warmer or cooler winters compared to the long-term average, but do not strongly affect precipitation [4]. It is currently not known how ENSO may change as global warming progresses.

Seasonal weather variability in the Puget Sound region, such as wetter and cooler weather during the winter and warmer, drier weather during the summer, results from changes in the movement of moisture-saturated air that reaches the Olympic and Cascade mountains. In addition, the Puget Sound region experiences geographic climate variability, as the way that air circulation interacts with topography can lead to drastic climate differences between areas within the Puget Sound region.

Using Climate Projections for Resilience Planning

Climate projections are an important tool for community and regional planning. In general, we recommend that resource managers and decisionmakers take a conservative approach to planning projects and investments by anticipating projected changes from a high emissions scenario (RCP 8.5). This approach can reduce the risk of being underprepared for climate impacts. However, decisions to build infrastructure to withstand more severe impacts (e.g., more extreme precipitation and flooding) require a review of the level of risk involved and how much risk decisionmakers are willing to accept.

OBSERVED TRENDS AND PROJECTED CHANGES FOR KEY CLIMATE DRIVERS

Temperature

Observed Trends

- During the 20th century, the **annual average temperature in Puget Sound lowlands warmed approximately 1.3 °F** (see Figure 2) [5].
- **All seasons have experienced warming, with statistically significant warming in the Seattle area during the spring and summer** [6]**.**
- **Nighttime heat events have increased in frequency** [7]**.**

The Puget Sound region has experienced long-term warming trends and more frequent nighttime heat events. The Puget Sound lowlands (see Figure 3) warmed approximately 1.3 °F between 1895 and 2014 [5]. In the same area, all seasons except for spring show statistically significant warming trends during this period (see Table 3). In Seattle, statistically significant warming occurred for spring and summer between 1895 and 2018 [8].

Figure 3. Puget Sound lowlands climate division, which includes all the low-lying areas surrounding Puget Sound indicated in the purple shaded area. The entire Puget Sound region is indicated in the pink shaded area. The analysis of observed changes for the Puget Sound lowlands was based on data from the U.S. Climate Divisional Dataset developed by the National Centers for Environmental Information **[4]**.

Nighttime air temperatures are increasing at a quicker pace than daytime air temperatures in the Puget Sound region. Daily minimum temperatures, which typically occur during the night, increased by 1.8 °F between 1895 and 2014. Daily maximum temperatures, which typically occur in the afternoon, warmed 0.8 °F over the same period. Additionally, the region's frost-free season, also known as the growing season, increased by 30 days between 1920 and 2014 [7].

Temperature data from Shoreline's specific location was not available across a long enough time period to determine long-term trends.

Table 3. Observed annual and seasonal trends in temperature. The asterisk (*) indicates the trend is not statistically significant **[5] [7] [8].**

Season	Temperature Change in Puget Sound, 1895-2014	Temperature Change in Seattle, 1895-2018
Annual	+1.3 °F (+.7 to +1.9°F)	+1.29°F
Fall (SON)	+.12 °F/decade (+.07 to +.17°F)	+0.7°F/decade*
Winter (DJF)	+.13 °F/decade (+.02 to +.24°F)	+0.9°F/decade*
Spring (MAM)	*No significant change*	+0.1°F/decade
Summer (JJA)	+.13 °F/decade (+.07 to +.19°F)	+0.17°F/decade
Frost-Free Season	+30 days (+18 to +41 days)	

Figure 4. Temperature change in the Puget Sound lowlands. The red line shows average annual temperatures for the Puget Sound lowlands region (see map in previous figure) between 1895 and 2014. The black horizontal line shows the average temperature from 1950-1999. The dotted red line represents the trend, indicating a warming of +1.3°F in average annual temperature between 1895 and 2014. Analysis is based on data collected at NOAA Cooperative Observer (COOP) stations in the Puget Sound Lowlands climate division (division 3 in Washington State) developed by the National Centers for Environmental Information **[4]**.

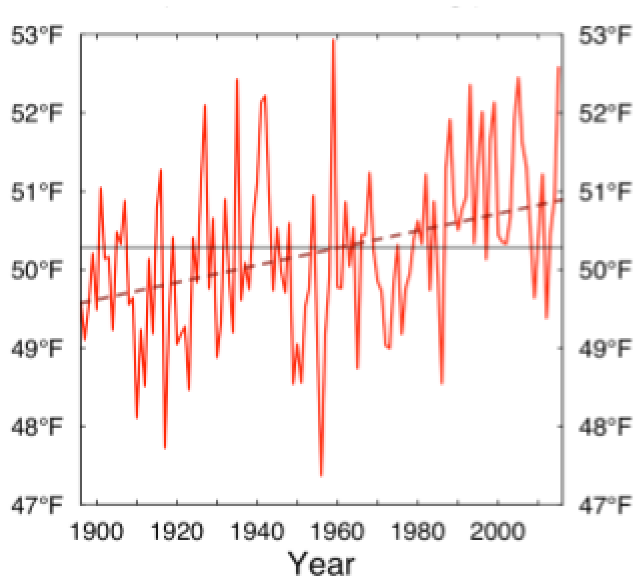
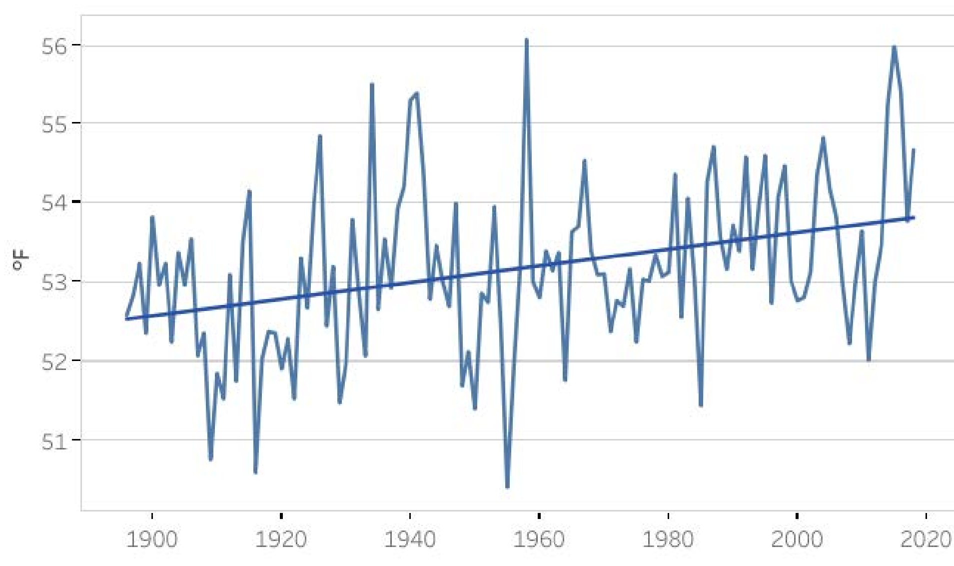


Figure 5. Annual average temperature in Seattle, 1896-2018. Annual average temperature increased 1.29°F between 1896 and 2018 based on data collected at an urban site in Seattle. The darker blue line shows the linear trend during that period **[8]**.



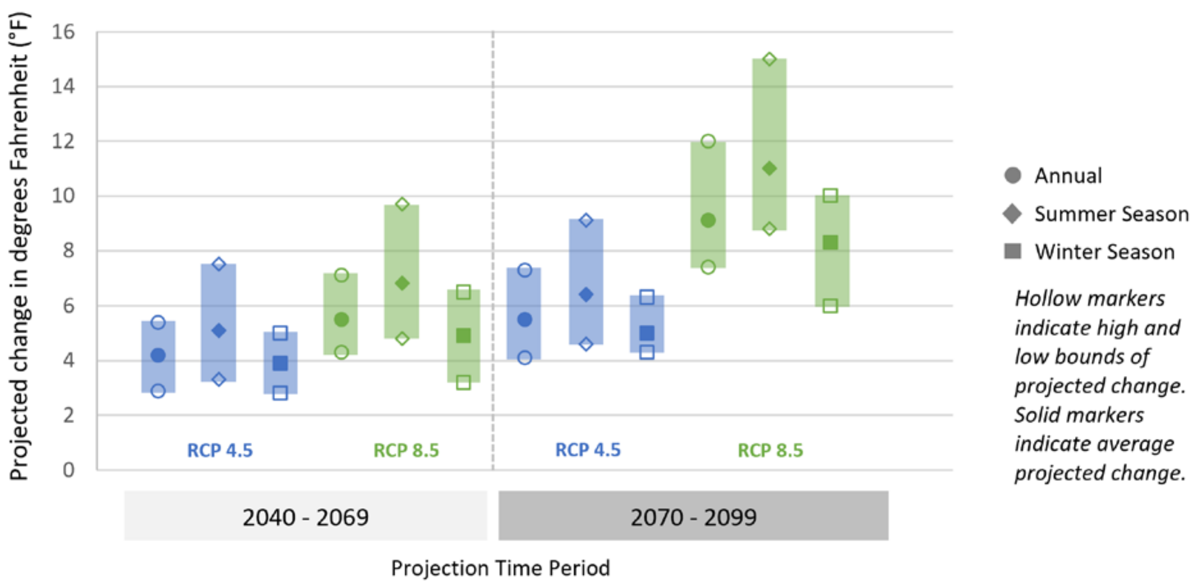
Projected Changes

- By the mid-21st century, **the average year in Washington will be warmer than the hottest year of the 20th century,** under a high-emissions scenario [9]**.**

- **By the mid-21st century, average annual temperatures in the Puget Sound region are projected to increase by 4.2 °F to 5.5 °F** under low- and high-emissions scenarios, respectively, compared to the 1970-1999 average (see Figure 6)**. By 2100, they are projected to be 5.5°F to 9.1°F warmer** under low- and high-emissions scenarios, respectively [9]**.**
- **Summer temperatures in Puget Sound are projected to increase**, with the hottest days of the year being 4.0°F to 10.2°F warmer by the mid-21st century compared to the 1970-1999 average [10]**.**

Warming is projected to continue in the Puget Sound region under all emissions scenarios and all seasons, with summer seeing the largest temperature increases [10]. Until mid-century, the anticipated average temperature increases are similar under all scenarios, since most warming in these years is the result of GHG emissions that have already occurred.

Figure 6. Projected changes in average annual and seasonal temperature for the Puget Sound region. All projected changes for the two time periods shown below (2040-2069 and 2070-2099) are relative to the average for 1970-1999. Average seasonal temperature refers to the change in average temperature for a given season: summer (June through August) or winter (December through February). The hollow markers indicate the range of projected change. This Figure was developed with data from CIG 2015 **[10]**.



The frequency and strength of extreme heat events are projected to increase, while extreme cold events are projected to decrease relative to the 1970-1999 average. Compared to that period, **the hottest days in the year for the Puget Sound region are expected to be 6.5 °F warmer and the coolest nights are projected to be 5.4 °F warmer by mid-century** (see Table 4).

A *degree day* compares the average daily temperature to a standard temperature to help assess climate and projected energy consumption and costs. The more extreme the temperature outside is, the higher the number of degree days and, generally, the higher the energy use for heating or cooling. A *cooling degree day* is a measure of how high the temperature is on a given day compared to a standard temperature of 75°F, a potential threshold for turning on air conditioning. For example, a specific day with an average temperature of 80°F equates to 5 cooling degree days. **Cooling degree days in the Puget Sound region are anticipated to increase by 17 degree days by mid-century compared to the 1970-1999 average** (see Table 4). This increase in cooling degree days indicates that the hottest days will be hotter, indicating more need for air conditioning to provide cooler indoor spaces.

A *heating degree day* is a measure of how cold the temperature is on a given day compared to a standard of 65 °F, which is when most heating systems turn on. **Heating degree days are expected to decrease by 1,600 degree days by mid-century compared to the 1970-1999 average** (see Table 4). This significant decrease in heating degree days indicates that the coldest days will be warmer, potentially requiring less energy to heat homes and indoor spaces.

A *growing degree day* is a measure to estimate the growth and development of plants and insects during the growing season and is measured against a standard temperature of 50 °F [4]. **Growing degree days in the Puget Sound region are projected to increase by 800 degree days by mid-century compared to the 1970-1999 average** (see Table 4). This change will support a longer growing season, giving crops more time to grow and potentially supporting more than one harvest each year for some crops. A longer growing season as well as warmer temperatures throughout the year may enable insects to survive year-round and increase their populations.

Table 4. Projected changes in Puget Sound region temperature extremes. All changes are relative to the average for 1970-1999. Temperature of hottest days represents the projected change in the 99th percentile of daily maximum temperature. Temperature of coolest nights represents the projected change in the 1st percentile of daily minimum temperature (Table adapted from CIG 2015 SOK) **[11]**.

Indicator	2040-2069			2070-2099		
	Average	RCP 4.5	RCP 8.5	Average	RCP 4.5	RCP 8.5
Temperature of hottest days	+6.5 °F	+4.0 °F	+10.2 °F	+9.8 °F	+5.3 °F	+15.3 °F
Temperature of coolest nights	+5.4 °F	+1.3 °F	+10.4 °F	+8.3 °F	+3.7 °F	+14.6 °F
Heating degree days	−1600 deg-days	−2300 deg-days	−1000 deg-days	−2306 deg-days	−3493 deg-days	−1387 deg-days
Cooling degree days	+17 deg-days	+5 deg-days	+56 deg-days	+52 deg-days	+6 deg-days	+200 deg-days
Growing degree days	+800 deg-days	+500 deg-days	+1300 deg-days	+1280 deg-days	+591 deg-days	+2295 deg-days

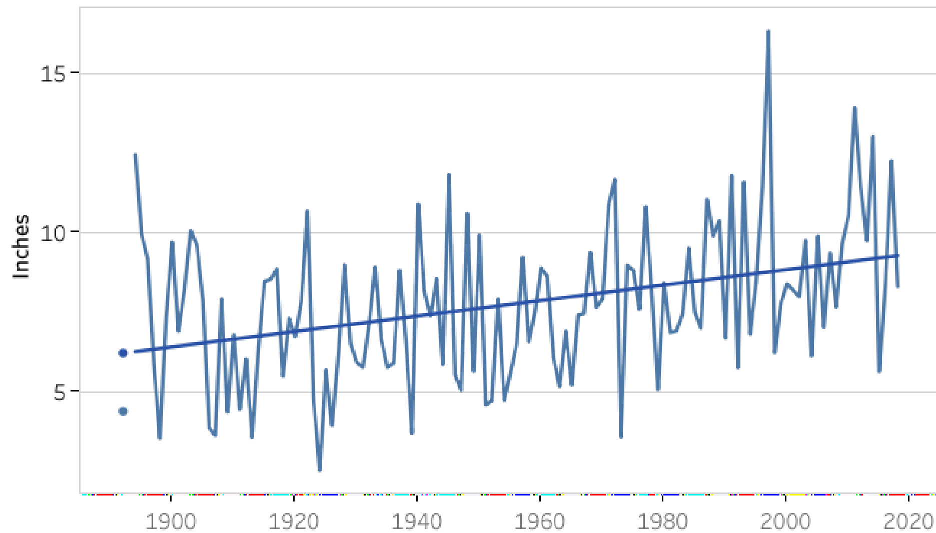
Precipitation

Observed Trends

- **Moderate increases in extreme precipitation events** have been observed in western Washington [4].
- **Spring precipitation increased by 27% in the Puget Sound lowlands** since the late 19th century. All other seasons show no significant trends in precipitation [6]**.**
- **Annual precipitation in the Seattle area increased by 1.8 inches** since the late 19th century [6].

The Puget Sound region has naturally variable precipitation patterns, causing fluctuations between wet and dry years, as well as between wet and dry decades [5]. Annual precipitation in Seattle showed a statistically significant increase of 1.8 inches between 1894 and 2018 [6]. Trends in seasonal precipitation (changes in total precipitation across the three months of each season from year to year) are typically insignificant; the exception is spring (March through May) precipitation, which increased by 27% in the Puget Sound lowlands region between 1895 and 2014 [4]. In Seattle, springtime precipitation increased by approximately 5% per decade between 1892 and 2018 (see Figure 7). Most studies of historical records have found that heavy rainfall in Western Washington has modestly increased in both frequency and intensity over the 20th century, but not all trends are statistically significant [4].

Figure 7. Spring precipitation in Seattle, 1892-2019. Springtime precipitation increased by 4.9% per decade between 1892 and 2018, as recorded at an urban site in Seattle (specific location in Seattle is not reported in data source). The darker blue line shows the approximate trend during that period **[6]**.



Projected Changes

- **Annual precipitation in the Puget Sound region is projected to increase** by 4% to 5% by the mid-21st century, and by another 2% by the late 21st century [4].
- **Wetter conditions are anticipated in spring, fall, and winter. Summer will continue to become drier** [4].
- Recent climate modeling shows the potential for **large increases in future rainfall intensities**; for example, showing a 27% increase in the 1-hr 25-year event and an 11% increase in the 24-hr 25-year event at the Boeing Creek precipitation station in the City of Shoreline [12].

Across the Puget Sound region, annual precipitation is projected to increase under both low- and high-emissions scenarios [4]. Most projections indicate an increase in precipitation intensity for the Puget Sound region for all seasons except for summer. **Heavy precipitation events are projected to become more frequent and intense.** King County anticipates significant increases in future precipitation intensity; for example, a 7% to 54% increase in the 10-year hourly rainfall event by 2080 (see Table 6) [11]**.** [5]

[5] Multiple climate scenarios and models were used to represent a range of possibilities of future precipitation, leading to a wide range in projected changes.

Table 5. Projected change in annual Puget Sound precipitation. All changes are relative to the average for 1970-1999. Values in the table are the average (and range in parentheses) of projections from 10 climate models chosen for their accuracy in representing the Pacific Northwest climate, based on both RCP 4.5 and RCP 8.5 (Table adapted from CIG 2015 SOK) **[4]**.

Period	Annual Precipitation Projection	
	RCP 4.5	RCP 8.5
2040-2069	**+4.2%** (+0.6 to +12%)	**+5.0%** (-1.9 to +13%)
2070-2099	**+6.4%** (-0.2 to +10%)	**+6.9%** (+1.0 to +9.4%)

Table 6. Projected changes (%) in precipitation statistics near SeaTac for the 2080s (compared to 1980s). Columns show the changes for RCP scenarios (4.5 and 8.5) for the full water year (Oct-Sep), winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Dec). Rows show the projected change in the total precipitation for each time period as well as statistics corresponding to the 2-, 5-, 10-, 25-, 50-, and 100-year events. Adapted from Table 8.1 in Projections in Changing Heavy Precipitation report **[11]**.

		Water Year		Winter		Spring		Summer		Fall	
		4.5	**8.5**	**4.5**	**8.5**	**4.5**	**8.5**	**4.5**	**8.5**	**4.5**	**8.5**
% change in total annual precipitation		5	4	2	9	-1	16	-38	-38	21	-5
% change in 1-hour precipitation	**2-yr**	21	32	23	17	19	36	-51	-18	14	28
	5-yr	13	45	19	39	24	35	-43	0	14	35
	10-yr	7	54	13	56	28	32	-39	10	17	37
	25-yr	-2	69	2	80	32	26	-34	22	22	37
	50-yr	-9	81	-6	100	36	22	-31	32	27	35
	100-yr	-15	94	-15	122	39	17	-28	41	32	34

Western Washington is known for its rainy conditions, and Shoreline is no exception. As climate change intensifies, precipitation variability will continue to increase, causing more frequent extremes between dry and wet days. Projected changes in precipitation extremes were developed using information from the Regional Model Projections of Heavy Precipitation for Use in Stormwater Planning online data tool [13].[6] Projections for the Boeing Creek (04u) rain gauge location were used for this analysis and are shown in the following tables and figures.[7] Future flow rates in Shoreline's surface water system have not been simulated, but it is reasonable to assume that the increases in precipitation intensity and frequency will result in higher future flow rates.

[6] The online tool allows users to access results from 12 different climate models projections for dozens of locations across Puget Sound and Washington State. The tool includes extreme precipitation projections for a range of variables, including rainfall event period (2-, 10-, 25-, 50-, and 100-year events), storm duration (1 to 360 hours), future time period (2030s, 2050s, and 2080s), and period of year (water year, seasons, and months).

[7] The Boeing Creek rain gauge station was the only Shoreline location that was included in the UW CIG study to develop projections for changes in heavy precipitation. While there are other rain gauges located in Shoreline, projections are not available for those stations.

Table 7. Projected changes (%) in total annual precipitation at Boeing Creek station for the 2080s (compared to 1980s). Columns show the changes for RCP 8.5 for the full water year (Oct-Sep), winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Dec). Values represent the median percent change among 12 climate models. Table created using data from CIG **[12]**.

	Water Year	Winter	Spring	Summer	Fall
% change in total annual precipitation	13	17	10	-20	10

Table 8. Projected changes (%) in 2-yr through 100-year precipitation events at Boeing Creek station for 1-hr through 360-hr durations for the 2080s (compared to 1980s). Projections are for RCP 8.5. Values represent the median percent change among 12 climate models. Darker shading for higher percent increase. Table created using data from CIG **[12]**.

Return Period	Percent Change for Give Event Duration										
	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr	48-hr	72-hr	120-hr	240-hr	360-hr
2-yr	25	25	22	18	17	20	20	17	16	17	15
5-yr	30	21	18	15	10	16	16	15	20	18	16
10-yr	32	25	24	16	12	12	16	16	18	18	17
25-yr	27	27	26	18	14	11	15	15	16	18	18
50-yr	25	28	25	18	15	7	13	15	16	18	18
100-yr	24	30	24	18	8	6	10	17	15	17	17

Projections for the Boeing Creek station show increases in precipitation extremes across most storm sizes and durations by the 2080s, with the most pronounced increases for short-duration events under a high-emissions scenario (RCP 8.5). Future changes for longer-duration precipitation events compared to historical trends are less clear; however, the overall trend in extreme precipitation is upward.

When applying these projections to planning and management decisions, there are several factors to consider:

- Projected changes for the Boeing Creek station in Shoreline are only available for the high-emissions scenario (RCP 8.5) at the time of writing this summary document. These projections are reflected in Tables 7 and 8. If projections under a low-emissions scenario (RCP 4.5) shown in Table 6 will also be considered, it is important to note that those projections are downscaled for a location near SeaTac and therefore do not provide a direct comparison to projections at the Boeing Creek station.
- Projected changes are always affected by a combination of random variability and climate change, and this is especially the case for changes in extreme events. Authors of the New Projections of Changing Heavy Precipitation in King County report recommend focusing on 2080 projected changes because, although they are still significantly influenced by natural variability, the last part of this century is when changes will be greatest relative to natural variability.
- The projected changes in extreme events are limited by sample size. While there are more observations of 2- and 5-year events in a 30-year record, there are relatively fewer observed events for 50- and 100-year extreme events. Therefore, a greater degree of extrapolation is needed to generate projections for 50- and 100-year events.
- The model used in this study statistically includes convective precipitation (i.e., thunderstorms), but it does not use a fine enough spatial scale to accurately capture these

events. This is most likely to affect projected changes in summer precipitation events, since thunderstorms are most prevalent during that season.

Figure 8. Projected changes in 1-hour precipitation extremes in Shoreline for the 2080s compared to the 1980s (RCP 8.5). Gray dots represent projected changes from a single climate model, green dots represent the median value among all 12 climate models, and vertical green lines represent the range of values **[11]**.

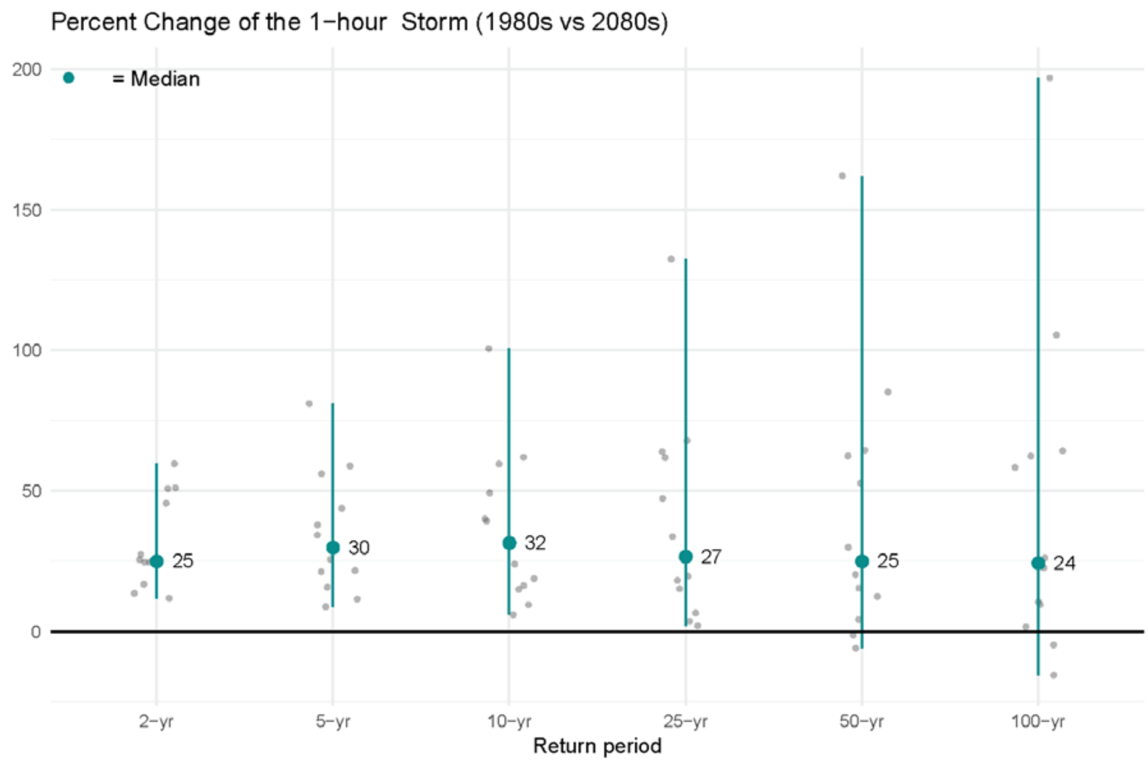


Figure 9. Projected changes in 2-hour precipitation extremes in Shoreline for the 2080s compared to the 1980s (RCP 8.5). Gray dots represent projected change from a single climate model, green dots represent the median value among all 12 climate models, and vertical green lines represent the range of values **[11]**.

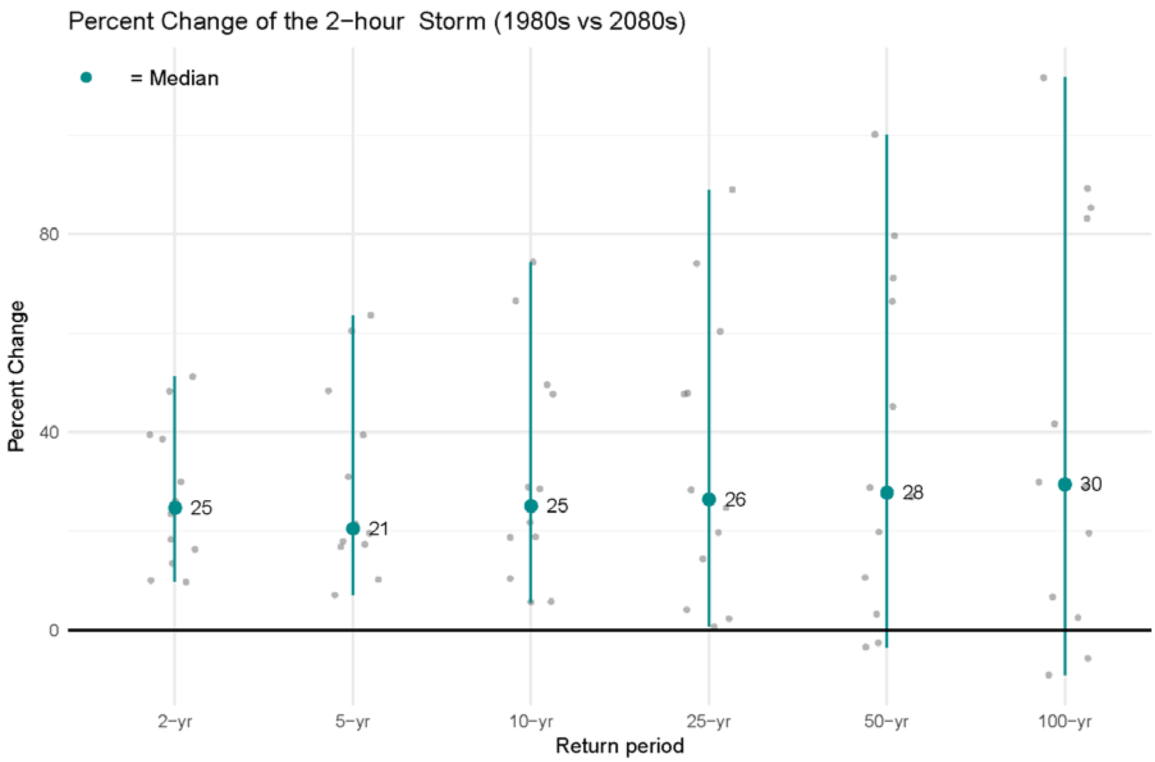


Figure 10. Projected changes in 24-hour precipitation extremes in Shoreline for the 2080s compared to the 1980s (RCP 8.5). Gray dots represent projected change from a single climate model, green dots represent the median value among all 12 climate models, and vertical green lines represent the range of values **[11]**.

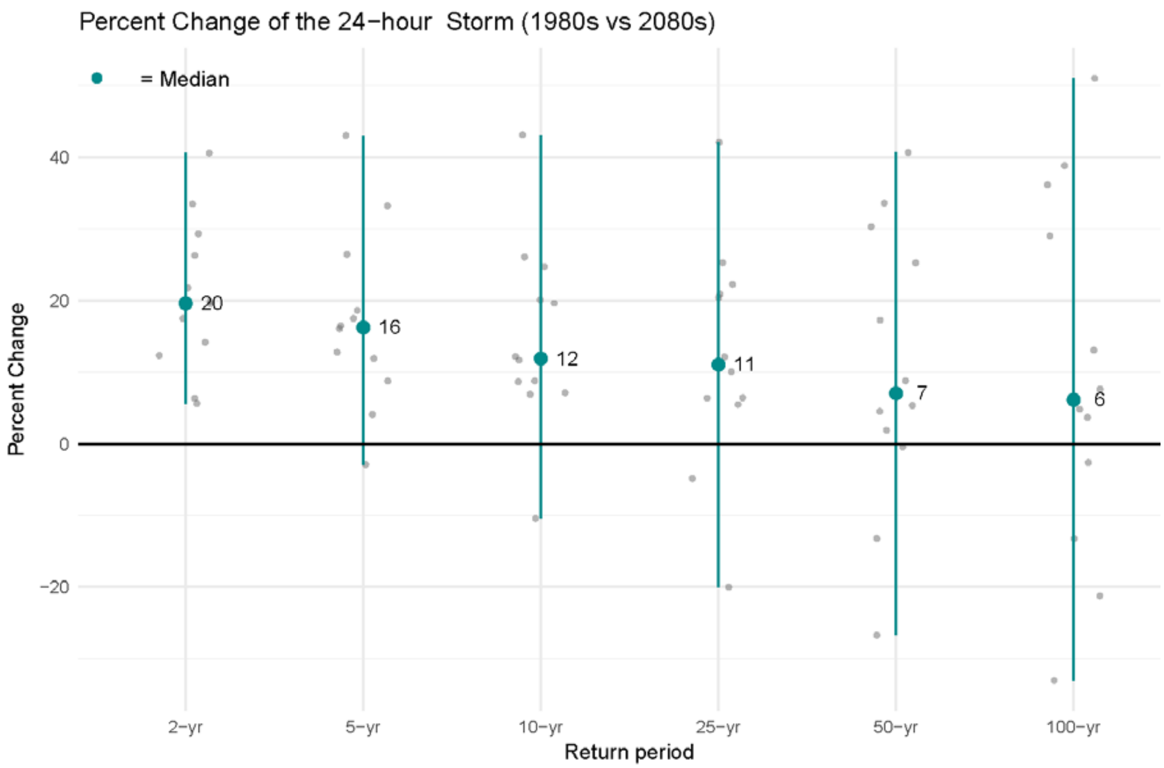
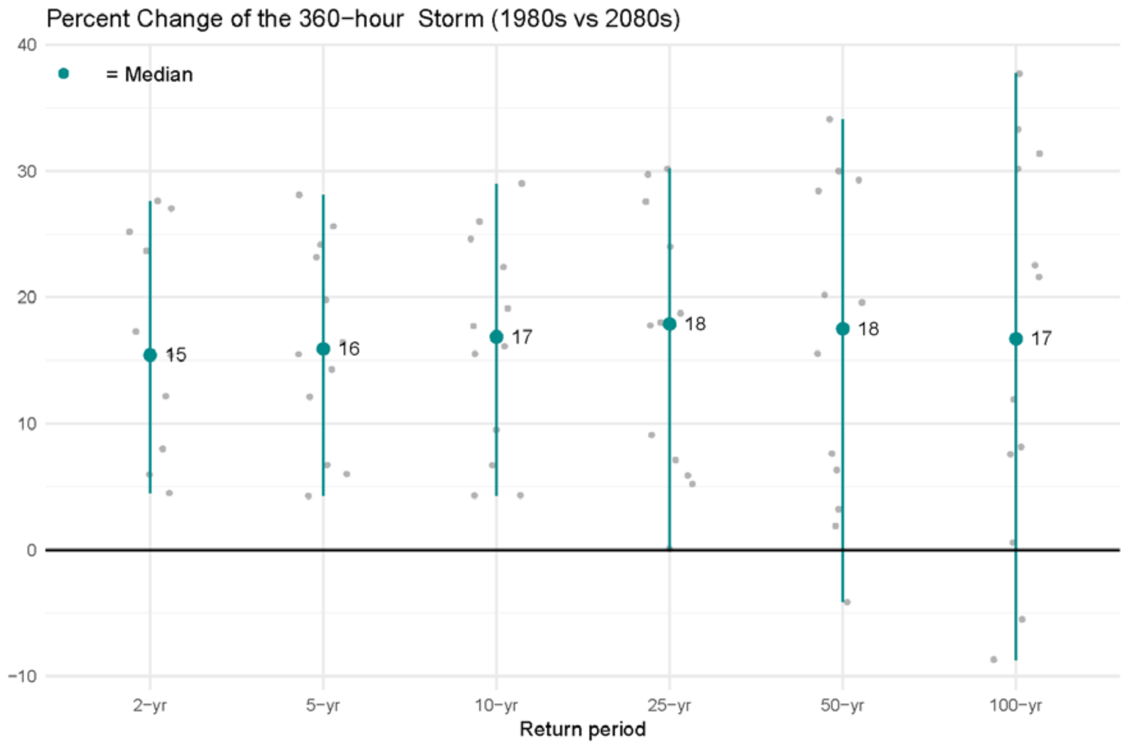


Figure 11. Projected changes in 360-hour precipitation extremes in Shoreline for the 2080s compared to the 1980s (RCP 8.5). Gray dots represent projected change from a single climate model, green dots represent the median value among all 12 climate models, and vertical green lines represent the range of values **[11]**.



Puget Sound Watershed Hydrology

Observed Trends

- **In the Cascades, spring mountain snowpack has declined about 25%** between the mid-20th century and 2006 [4].
- **Puget Sound glaciers are declining** in both number and volume [4].
- In Puget Sound rivers, **the timing of peak streamflow is shifting earlier in the year** [4].

The Tolt and Cedar Rivers are the primary sources of drinking water for the City of Shoreline; therefore, changes in hydrology along the western slopes of the Cascade Mountain have the potential to influence water supply availability. Changes in mountain river hydrology, such as changes in the amount of snowpack and rate of streamflow, are driven by changes in temperature, heavy rainfall events, and seasonal precipitation. Current long-term trends in snowpack indicate a significant decline. Between the mid-20th century and 2006, the Washington Cascades spring snowpack has decreased approximately 25%, or almost 4% per decade [4].[8]

Most glaciers in the broader Puget Sound watershed (see Figure 2) are in decline, not only in glacier area, but also in terms of the total number of glaciers remaining. Between 1900 and 2009, glacier area in the North Cascades declined by 54% [4].

Current trends in annual streamflow across the Puget Sound watershed are mixed and there is no statistically significant trend in annual average streamflow. However, dry years are becoming drier for some rivers, and peak streamflow is shifting earlier in the spring for watersheds that collect snowmelt; it has moved up to 20 days earlier in some rivers between 1948 and 2002 [4].

Projected Changes

- As temperatures increase, **snowpack is projected to decline** in Puget Sound watersheds and **spring runoff is expected to shift earlier** in the year. **Summer streamflow is anticipated to decline** significantly across Puget Sound watersheds, including in the Cedar River Watershed. This has implications for regional water supply [4].
- **The risk of flooding is expected to increase** as more precipitation comes in the form of rain and as the heaviest 24-hour rain events become more severe and more frequent [4].

As the climate warms, the Pacific Northwest is projected to continue to face decreased snowpack and changes to streamflow timing and seasonal minimums. By the end of the 21st century, based on the RCP 4.5 scenario, the main form of precipitation in Puget Sound basins is expected to be rainfall [4]. Puget Sound watersheds that are currently dominated by a mix of rain and snow in the winter are projected to become progressively more rain-dominant. The Tolt River Watershed and Cedar River Watershed are projected to transition from mixed rain-snow basins to rain-dominant basins by the 2040s (see Figure 12).

This transition towards mostly rainfall precipitation is projected to lead to an increase in winter streamflow and an earlier peak streamflow. In the Cedar River watershed, the peak streamflow is projected to be 37 days earlier in the year [4].[9] Projected increases in winter precipitation and streamflow are expected to increase the risk of flooding in the Puget Sound region. Summer streamflow is projected to decline, due to decreased summer precipitation and increased summer temperatures, which cause more evaporation [14]. The greatest and most consistent declines in minimum streamflow during the summer will be in rain-dominant and mixed rain and snow basins, such as Tolt and Cedar Watersheds, indicating more limited in-stream water availability during the summer months. In the Cedar River, streamflow minimum is projected to decline by 25% by the 2080s compared to the 1970-1999 average [4].

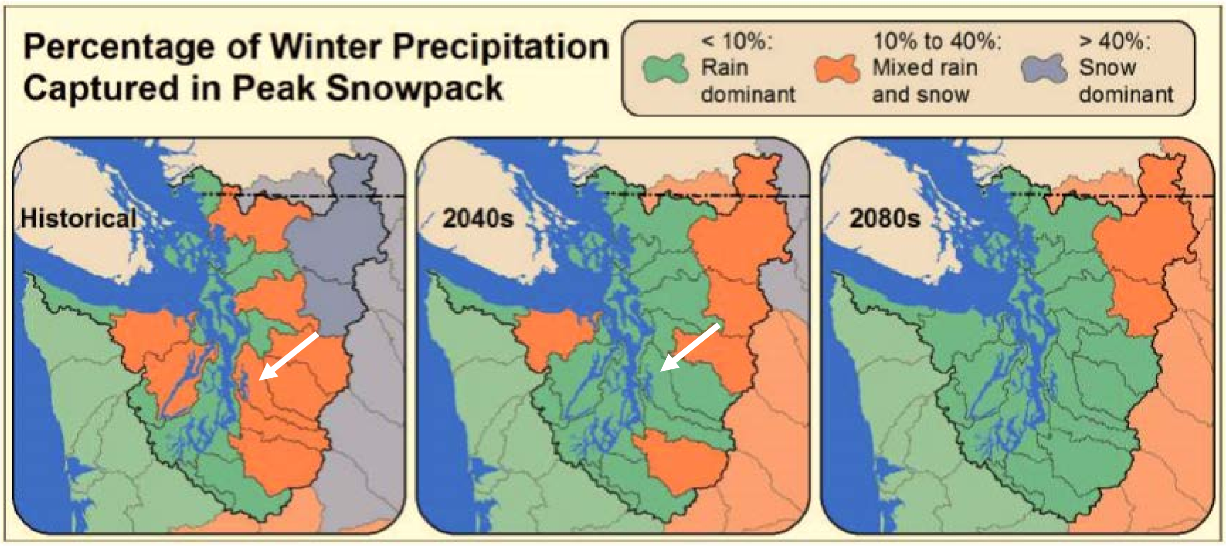
As more precipitation comes in the form of rain, as winter precipitation increases, and as the heaviest 24-hour rain events are projected to become more severe, flooding risk is expected to increase. Regional models

[8] Snowpack is directly measured using automated Snowpack Telemetry (SNOTEL) at various stations in the Cascades and Olympics. Studies may also use other data to determine long-term trends in snowpack, such as streamflow, precipitation, temperature, and the water-balance snowpack estimate.

[9] This projection is based on a moderate GHG emissions scenario from a previous model that most closely aligns with RCP 6.0, an average between RCPs 4.5 and 8.5.

anticipate that the heaviest 24-hour rain events in Western Washington will intensify by 22% on average by the 2080s relative to the 1970-1999 average [4]. These events are projected to be more frequent, occurring about 7 days more per year, compared to 2 days per year historically.

Figure 12. Model projections of Puget Sound watersheds suggest a transition to largely rain-dominant basins by the 2080s. The white arrow indicates the location of the Tolt and Cedar River Watersheds **[4]**.



Sea Level Rise and Storm Surges

Observed Trends

- Global sea level has risen **8 inches between 1900-2009** [15]**.**
- On average, sea level in Puget Sound has risen **0.8 inches per decade between 1900-2009** [4].
- There is **no long-term trend in storm surge**.

Global sea level has risen approximately 8 inches between 1900 and 2009, or 0.7 inches per decade [15]. The rate of rise has increased in more recent years: global sea level rose 1.3 inches per decade from 1993 to 2010. The rate of sea level rise since the mid-1800s is faster than any rate during the last two millennia [15].

In Puget Sound during the last century, sea level rose at most of the region's shorelines. Rates at which sea level rose varied depending on local land motion, weather patterns, and ocean currents [4]. At the Seattle tide gauge, which has one of the longest records of data in Puget Sound, sea level rose 8.6 inches between 1900 and 2008 [4]. There are no observed trends for changes in local sea level rise in Shoreline specifically.

During winter months, and even more often during El Niño events, wind combines with the effects of Earth's rotation to further push ocean water toward the shore, causing an elevated sea level. In the Puget Sound, this results in an approximately 20-inch rise in sea level during the winter, compared to the summer. During El Niño events, sea level can be as much as 12 inches higher than normal for several months at a time [16].

Currently, there are no published studies looking at trends in storm surge within Puget Sound. However, one study found that trends in storm surge along the Northwest coast are purely a reflection of rises in sea level, in contrast to an increase in storm intensity [17].

Projected Changes

- In Washington, the latest projections available indicate that rates of **both absolute and relative sea level rise are projected to increase across both high- and low-emissions scenarios by 2150** (see Table 8 and Table 9) [18].
- Between 2050 and 2100, **absolute sea level rise in Puget Sound is projected to nearly triple** [18].
- By 2100, **relative sea level rise is projected to rise 2.0 to 2.5 feet in Shoreline** [18].
- **Sea level rise increases the potential for increased storm surge reach and increased coastal inundation, erosion, and flooding.** Even minor rises of sea level can potentially shift the risk of coastal hazards in substantial ways [18].

The rate at which sea level rises in Puget Sound depends on the rate of global absolute sea level rise and on regional factors such as ocean currents, wind patterns, location, and elevation. In areas where the land is sinking, the regional relative sea level rise will be greater than the absolute sea level rise, and in regions where the land is rising, relative sea level rise will be less than the absolute sea level rise.

Ocean processes (such as thermal expansion from warming waters), land-based glacier and ice cap melt, and ice sheets also impact global sea level change. Additionally, rises in sea level can occur from melting land and sheet ice from Greenland and Antarctica.

Understanding Sea Level Rise

Absolute sea level rise is the height of the ocean surface relative to a fixed, unmoving reference point, such as the center of the earth. The impacts of sea level rise will be felt via a change in height of the ocean surface relative to land. **Relative sea level rise projections** combine separate estimates of absolute sea level rise and vertical land movement (uplift or subsidence) [18].

Sea level rise projections are presented with the “likelihood of exceedance,” or the probability that sea level will meet or exceed a certain amount. Likelihood is an important factor when considering the level of risk involved. Using a low-likelihood projection (e.g., 1%) as the given scenario for planning and decision-making is a more conservative approach because it means preparing for more significant changes that are relatively less likely to occur. In contrast, using a high-likelihood projection (e.g., 99%) as the given scenario is a less conservative approach because it means preparing for less significant changes that are more likely to occur. There is no single correct decision about what likelihood to use for decision-making; the decision depends on financial, logistical, and political factors specific to Shoreline. In this document, sea level rise projections are provided for 1%, 50%, and 99% likelihoods of exceedance.

It is highly likely that Shoreline will experience sea level rise. The rate and level to which sea level rises is dependent not only on emissions scenarios, but on tectonic influences as well. **The relative rise in sea level for Shoreline is projected to be between 2.0 feet and 2.5 feet higher by 2100 compared to 1991-2009**, based on low- and high-emissions scenarios and a 50% likelihood of exceedance (see Figure 13 and Figure 14). [18]. Note that the projections given here for relative sea level rise in Shoreline factor in a vertical land movement estimate of -0.5 ± 0.1 feet per century [18]. The projections do not factor in any additional land level change of 0.0 to -0.2 feet that may occur in this area due to a subduction zone earthquake, which would result in raising local relative sea level.

Figure 13. Projected changes in relative sea level rise (in feet) in Shoreline compared to the 1991-2009 average. Projections given for RCPs 4.5 and 8.5 for three different likelihoods (%) of sea level rise reaching or exceeding given levels **[19]**.

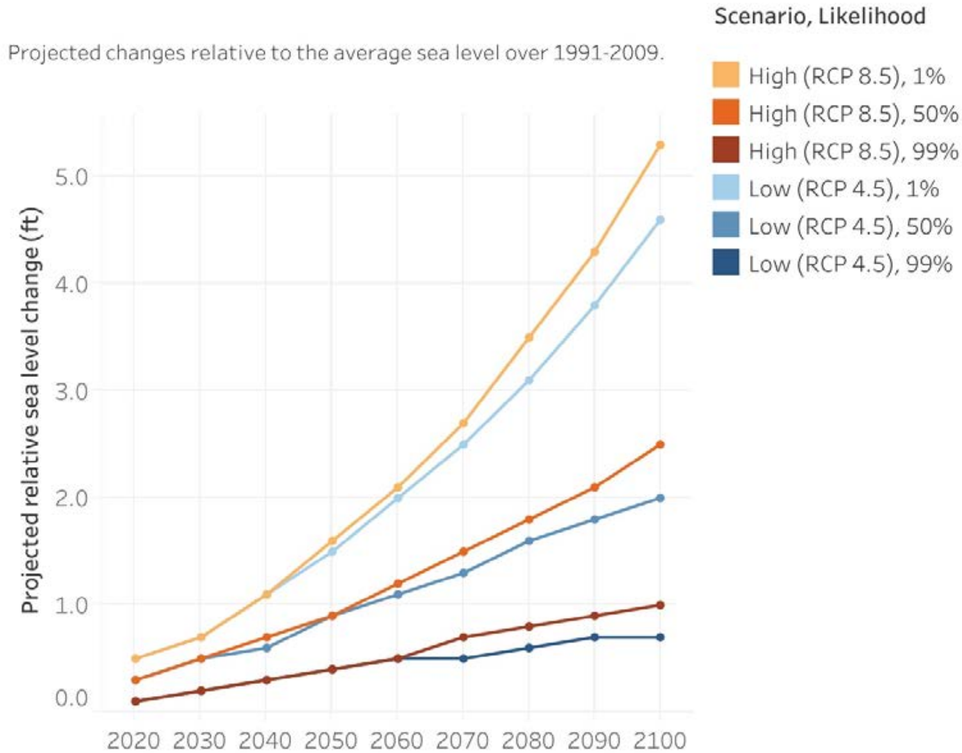
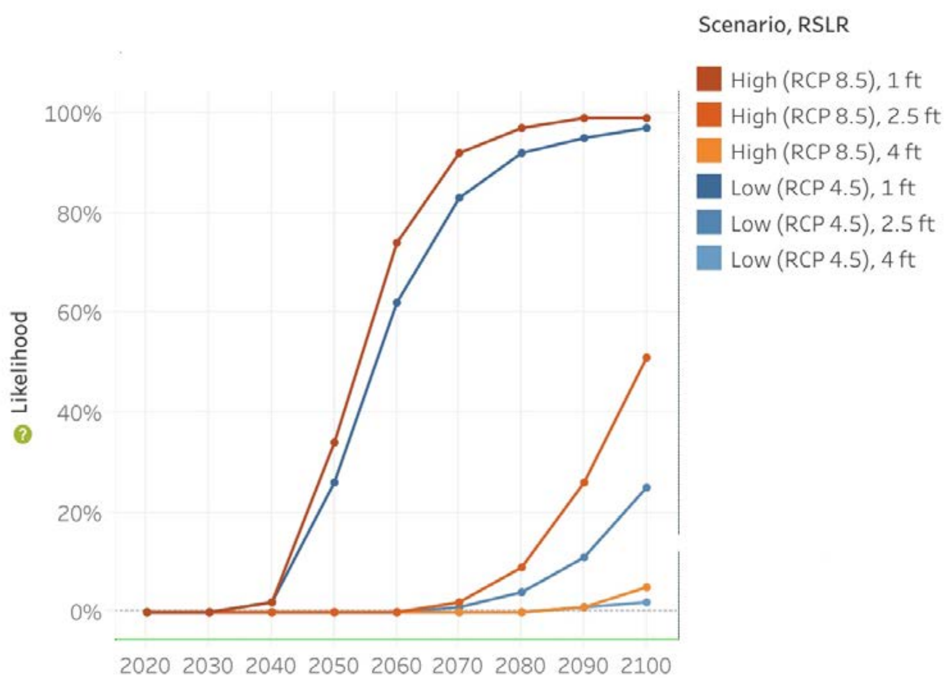


Figure 14. Likelihood of a given change in relative sea level rise in Shoreline compared to the 1991-2009 average. Likelihood is given for three different levels under low- and high-emissions scenarios (RCP 4.5 and 8.5) **[19]**.



CONCLUSION

This memo reflects the latest climate change research available for the Puget Sound region and for the City of Shoreline, as of October 2019. The findings suggest that climate change has been ongoing for decades and is expected to create many kinds of new and increased challenges in the region in the future. A summary of observed trends and projected changes is provided in Table 9.

Table 9. Summary of observed trends and projected changes in climate for the Puget Sound region and the City of Shoreline.

		Projected Changes	
Impact	**Observed Trends**	Low Emissions Scenario (RCP 4.5)	High Emissions Scenario (RCP 8.5)
Temperature	Average year is 1.3 °F warmer in Puget Sound than historic averages.	**By mid-21st century (vs 1970-1999 average)** 4.2°F increase in average annual temperature in Puget Sound. The hottest summer days will be 4.0°F warmer.	**By mid-21st century (vs 1970-1999 average)** 5.5°F increase in average annual temperature in Puget Sound. The hottest summer days will be 10.2°F warmer.
Precipitation	Moderate increases in extreme precipitation events have been observed in Western Washington.	**By the 2080s (vs 1980s)** 6.4% increase in annual precipitation in Puget Sound. Winters will be wetter and summers drier. *RCP 4.5 precipitation projections are unavailable for Shoreline specifically, so it is recommended to not directly compare them to RCP 8.5.*	**By the 2080s (vs 1980s)** 27% increase in 1-hr 25-year event and 11% increase in 24-hr 25-year event in Shoreline. Summers will be about 20% drier.
Puget Sound Hydrology	Streamflow minimums in Puget Sound rivers are becoming smaller and the timing of streamflow is shifting earlier.	**By the 2080s (vs 1970-1999 average)** Lower summer streamflows. Greater flooding risk. Both Tolt and Cedar River watersheds will become rain-dominant.	
Sea Level Rise	Sea level has risen 0.8 inches per decade in Puget Sound between 1900-2009.	**By 2100 (vs 1991-2001 average)** 2.0-foot rise in relative sea level in Shoreline. Increased risk of coastal inundation, erosion, and flooding.	**By 2100 (vs 1991-2001 average)** 2.5-foot rise in relative sea level in Shoreline. Increased risk of coastal inundation, erosion, and flooding.

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How will Climate Change impact the City of Shoreline?

Bird's eye view of the City of Shoreline.

The table below shares information on historic trends and anticipated changes for our community as our climate changes. This information is based on the latest climate change research for the Puget Sound region and the City of Shoreline. This research shows that climate change has been occurring for decades and is expected to continue in the future. We anticipate that climate change will create some new challenges for our community, and also worsen some existing challenges.

Risk	Trends to Date	Projected Changes
Temperature	The average year in the Puget Sound region is currently 1.3°F warmer than historic averages.	**By the 2050s (vs 1970-1999 average)** Average annual temperature in the Puget Sound region will be 4.2°F to 5.5°F warmer. The hottest summer days will be 4.0°F to 10.2°F warmer.
Precipitation	Extreme rain events in Western Washington have increased moderately.	**By the 2080s (vs 1980s)** Annual precipitation in the Puget Sound region will increase at least 6.4 percent. Rainstorms in Shoreline will be more intense. Winters will be wetter and summers drier.
Puget Sound Hydrology	Puget Sound rivers have lower streamflows during the summer, and streamflow peaks earlier in the year, leaving streams drier in the late summer and fall.	**By the 2080s (vs 1970-1999 average)** Summer streamflows will be even lower. Flooding risk will increase during the fall, winter, and spring. The Tolt and Cedar River watersheds (which supply Shoreline's drinking water) will have less snowpack to source water from.
Sea Level Rise	Sea level has risen 0.8 inches per decade in Puget Sound between 1900-2009.	**By 2100 (vs 1991-2001 average)** Relative sea level in Shoreline will rise 2.0 feet or more, resulting in greater risk of coastal erosion and flooding.

Shoreline's Vulnerability to Climate Change Impacts

What is climate change?

Climate change refers to a long-term change of temperature and typical weather patterns in a place. Climate is different from weather because it is measured over a long period of time, while weather can change from day to day or year to year. Human activity is the cause of current climate change. Burning fossil fuels—like natural gas, oil, and coal—releases greenhouse gases into Earth's atmosphere. These gases trap heat from the sun's rays inside the atmosphere causing Earth's average temperature to rise. The warming of the planet impacts local and regional climates. Throughout Earth's history, climate has continually changed. When it occurs naturally, this is a slow process over hundreds and thousands of years. The human-influenced climate change that is happening now is occurring at a much faster rate. *(NaturalGeographic.org)*

The City of Shoreline completed a vulnerability assessment in 2020 to:

- ✓ **Better understand** how climate change may impact the community, environment, and City infrastructure (roads, buildings, etc.).
- ✓ **Identify strategies** for building resilience to climate change impacts.

The results of the vulnerability assessment are summarized below.

HIGH VULNERABILITY

- Low-Lying Areas
- Sensitive Ecosystems
- Buildings and Development
- Heat-related Illnesses
- Air Quality

MODERATE VULNERABILITY

- Storm Drains
- Pipes, Ditches and Culverts
- Parks and Open Space
- Urban Trees
- Housing
- Mental Health Stress

LOW VULNERABILITY

- Transportation
- Emergency Services
- Vector-borne Diseases

WHAT IS SHORELINE DOING?

- The City of Shoreline is one of 18 partners participating in the **King County-Cities Climate Collaboration** to coordinate and enhance the effectiveness of local government climate and sustainability action.
- The City adopted its **Climate Action Plan** in 2013, committing to reduce community greenhouse gas emissions 80 percent by 2050. The Plan also included 45 recommended actions to reduce future climate change impacts for the Shoreline community. As of December 2019, roughly 87 percent of those actions have been implemented.

For more information, see individual factsheets with information about our built environment; public health, safety, and emergency services; stormwater; and natural ecosystems.

STORMWATER

VULNERABILITY TO CLIMATE CHANGE

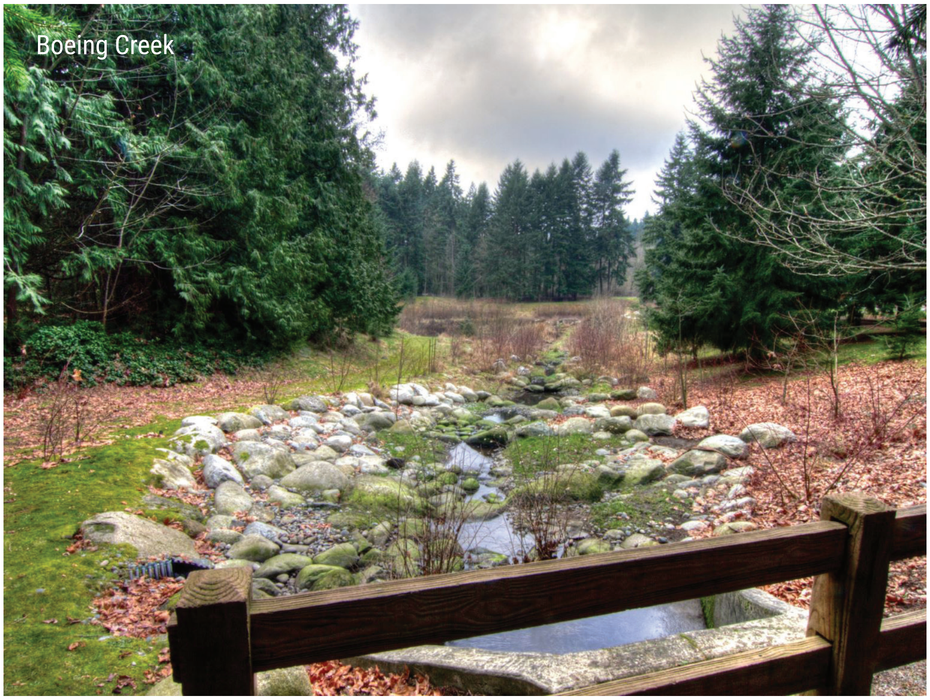
Rainstorms in Shoreline will likely be heavier in the future, requiring the surface water infrastructure to carry more rainwater. Flooding may occur in new places or worsen in parts of the City that already experience flooding.

Shoreline communities are likely to face the following impacts of a changing climate:

Low-Lying Areas
HIGH VULNERABILITY
Larger rainstorms make it more likely that low-lying areas will flood.

Storm Drains
MODERATE VULNERABILITY
More intense rainstorms may overwhelm storm drains.

Stormwater Pipes, Ditches, and Culverts
MODERATE VULNERABILITY
Some pipes and culverts are too small to handle additional rainfall.


Boeing Creek

What is the surface water system?

A network of drains, pipes, pumps, and culverts that carry rainwater into nearby streams, lakes, and ultimately Puget Sound. Rainwater that runs off surfaces in urban areas is often untreated, meaning it may carry oil and other pollutants from streets into Shoreline's waterbodies.

LOW-LYING AREAS

High vulnerability because they are more likely to be flooded during larger storms than other parts of the City, and ways to address these problems are expensive.

Heavy rainstorms are projected to become more frequent and intense in Shoreline's future. By 2080, large rainstorms are expected to be 10 to 30 percent larger than they were in the 1980s. Several low-lying areas in Shoreline are already prone to flooding, including the areas around Ronald Bog, Brugger's Bog, and areas near stormwater pump stations, which may be less able to handle the greater amount of water from these larger storms. In other low-lying areas, the lack of pipes or ditches may also create challenges.

Inequitable impacts from flooding

The impacts of flooding can cause disproportionate burden on some households in Shoreline. Lower-income residents may face a greater financial setback when fixing property damages from flooding. Residents with disabilities or limited mobility may have greater difficulty accessing public transit or other services during a flood.

STORM DRAINS

Moderate vulnerability due to more rainwater that may overwhelm and clog some drains, but some low-cost options can help reduce clogging and flooding.


Storm drain

Storm drains collect rainwater that falls in the street and funnels it into the surface water system. Leaves, branches, dirt, and trash can clog storm drains, causing localized flooding and sometimes blocking streets.

Street flooding can interfere with emergency response routes for firefighters and medical assistance. Vulnerable populations, including people with health conditions and older people, may be more adversely impacted by delays in emergency medical services or access to healthcare facilities. Flooding can also disrupt regular work commutes and may lead to missed days of work for people who cannot work from home, potentially posing financial hardship from lost wages.

Some neighborhoods in Shoreline may experience flooding due to drains clogged by leaf litter. Rainstorms are projected to become more intense in the future, so it will be even more important to make sure that drains are clear of debris to prevent flooding.

STORMWATER PIPES, DITCHES, AND CULVERTS

Moderate vulnerability due to more flow that stresses infrastructure. Some pipes are already too small to handle current flows.

Shoreline's surface water system includes pipes, ditches, and culverts. Culverts are designed to carry streams beneath roads, trails, and other crossings. Culvert crossings are found along most streams in the City, including McAleer Creek, Boeing Creek, and Thornton Creek and their tributaries.

Stream crossings are especially sensitive to higher levels of stormwater. If the culvert is too small, streams can back up and flood low-lying areas, roads or trails, and sometimes wash roads away. Roadway flooding can interfere with commuting, access to critical health services, and emergency response routes.

Some stormwater pipes in Shoreline empty directly into Puget Sound. These pipes will likely be exposed to rising sea levels and may require further evaluation to determine how those changes may impact flooding.

Culverts

WHAT IS SHORELINE DOING?

- **Surface Water Master Plan:** adopted by the City in 2018, this plan includes programs and projects to improve rainwater management, many of which increase the surface water system's resiliency to changes in climate.
- **Adopt-A-Drain program:** through this program, resident volunteers check on drains during the rainy season and keep them clear to help protect streets, homes, and properties from flooding.
- **Soak It Up rebate program:** this program offers rebates to homeowners and businesses for installing rain gardens or native vegetation landscaping to help reduce rainwater runoff.
- **Requirements and regulations:** the City requires new construction developers to install systems that store rainwater, allow it to soak into the ground, and slow its flow to low-lying areas and streams.
- **Monitoring:** before and after every major rain event, the City checks on all known vulnerable areas in the surface water system to ensure it is fully functional and to identify and address concerns.
- **Modeling:** modeling helps (1) identify weaknesses and areas most sensitive to more rainwater and (2) prioritize projects for improvements (e.g., larger pipes).

WHAT IS SHORELINE DOING? (Cont'd)

Additional strategies that Shoreline is planning or could pursue to build climate resilience include:

- **Conducting more frequent street sweeping** in known problem areas to prevent leaves from clogging drains and causing flooding.
- **Installing larger culverts and modifying design standards** to handle increased streamflows during heavy rain events.
- **Improving storage capacity upstream** helps slow down the sudden rush of flood waters during heavy storms.
- **Using more nature-based solutions** (e.g., rain gardens, bioretention, green roofs, bio-swales, cisterns, permeable pavement) in the urban landscape, such as in redevelopment projects, to encourage rainwater to soak into the ground and reduce localized drainage problems.
- **Redesigning pump stations** to improve the control of water flowing downstream during heavy rainstorms without increasing flood risk to areas around the pump stations.

Children at Echo Lake

NATURAL SYSTEMS

VULNERABILITY TO CLIMATE CHANGE

Warmer temperatures, wetter winters, and drier summers may impact the health and functioning of Shoreline's natural systems. These changes may increase stress on plants and animals that live in our most sensitive ecosystems.

Shoreline communities are likely to face the following impacts of a changing climate:

Sensitive Ecosystems

HIGH VULNERABILITY

Wetter winters and hotter, drier summers may further stress wetlands, water bodies, and other ecosystems and the threatened and endangered fish and wildlife that inhabit these areas.

Parks and Open Spaces

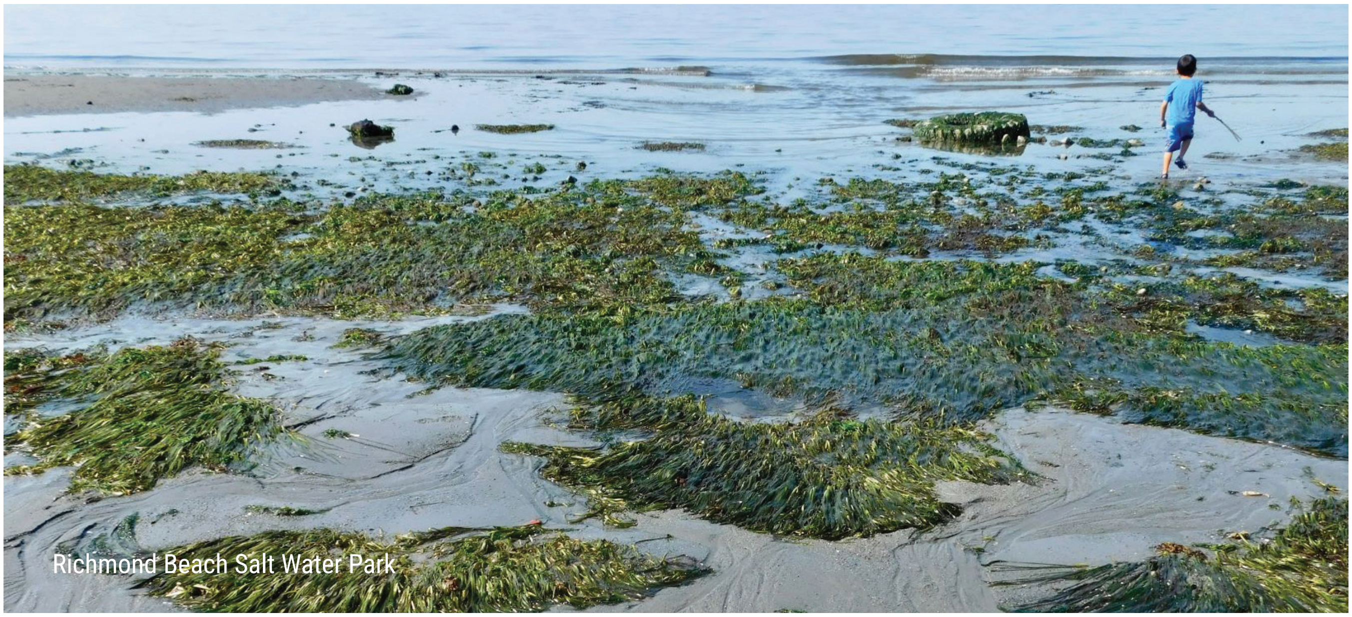
MODERATE VULNERABILITY

Warmer temperatures and more flooding may stress parks and open spaces, especially in places with paved surfaces and frequent use.

Urban Trees

MODERATE VULNERABILITY

Hotter summer temperatures and drought, as well as pests and diseases, may harm trees. Tree canopy may be lost in some areas from development.



Richmond Beach Salt Water Park

SENSITIVE ECOSYSTEMS

High vulnerability due to existing stress from human activities and the complex challenge of restoring natural systems.

Shoreline's natural systems include forested, shrub, and meadow plant and animal communities. They also include marine environments, freshwater streams, and freshwater wetlands and ponds. These natural systems provide many ecological functions and provide habitat for protected species (protected from harm under federal or state policy), including threatened and endangered species and species of concern.

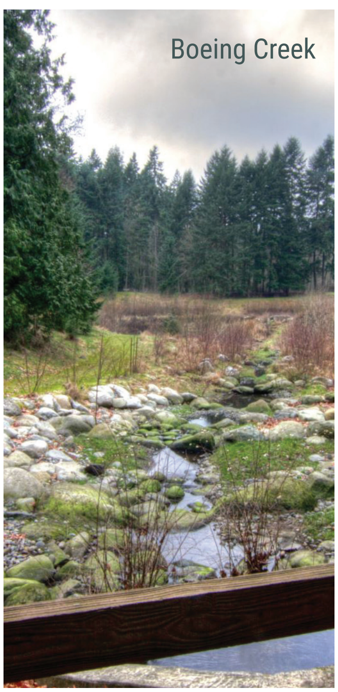
FRESHWATER STREAMS

Freshwater streams in Shoreline are vital to numerous species, for example:

- **McAleer Creek** is the only stream in the city with threatened Chinook salmon and steelhead trout.
- **Boeing Creek and Storm Creek** discharge directly to Puget Sound, a critical habitat for Southern Resident Killer Whales.
- **The marine shoreline and the Boeing Creek delta** (where the creek flows into Puget Sound) are an important migration route for salmon. Coho salmon (a species of concern) are present in lower reaches of Boeing Creek and in the tributaries to McAleer and Lyon creeks.

Freshwater streams are important to all life stages of salmon and Pacific lamprey. In the future, increased winter rainfall may cause higher water levels in streams, more flooding, and more erosion. Higher and faster streamflows can scour spawning beds and flush out juvenile salmon and other species. Flooding may also bring more pollutants into the streams, which may worsen as the city's population grows.

During the summers, less rainfall is likely to reduce water levels in streams, contributing to warmer water temperatures and reduced water quality. Since salmon need cold, clean water, poor water quality is likely to make it harder for salmon to survive in freshwater streams.


Boeing Creek

FRESHWATER WETLANDS AND WATERBODIES

Wetlands and ponds are important to species of concern, such as the western pond turtle. These natural systems are already stressed by disturbances from human activity, making them very sensitive to climate change impacts.

- Freshwater wetlands and other waterbodies in Shoreline, including Echo Lake, Ronald Bog, and Twin Ponds, will be **wetter in the winter and drier in the summer** due to climate change.
- **Changes in the movement, availability, distribution, and quality of freshwater** will likely make survival more difficult for wetland-adapted species, notably amphibians and certain bird species. These species depend on reliable water levels to survive. While these species may be negatively impacted by climate change, some **invasive species** (species that are not native to an ecosystem and cause harm) have adapted to changing conditions and as a result, are more likely to thrive and compete for habitat and resources with our native species.
- Warmer temperatures, combined with pollution from pet waste, fertilizers, leaf litter, and other nutrient-dense sources, may **worsen algal blooms** (groups of algae that grow out of control and produce toxic or harmful effects) in lakes, such as Echo Lake.

MARINE AND ESTUARINE ENVIRONMENTS

Marine and estuarine (mix of saltwater and freshwater) wetlands are present along the city's entire shoreline. This habitat is vital to several life stages of forage fish (surf smelt, herring, and sand lance), salmon, and Pacific lamprey. Climate change is expected to impact Richmond Beach Saltwater Park and the coastal portions of the Richmond Beach neighborhood (west of the BNSF railroad track). Projected impacts include:

- Beaches, tidal wetlands, mudflats, and eelgrass beds are likely to be degraded by **rising temperatures and higher tides**.
- **Rising sea levels** will likely cause **more frequent flooding** of coastal areas, which may **change characteristics of the landscape**. Sea level rise and flooding may cause habitats near the shore to change into different habitats over time.
- **Species relying on disappearing habitat types may be forced to move** or their populations may decline. For instance, estuarine beaches provide spawning habitat for forage fish, which may be diminished with sea level rise.
- When the ocean absorbs increased levels of carbon dioxide from the atmosphere, waters become more acidic. **Ocean acidification can corrode the shells of oysters and other shellfish, slowing growth and increasing mortality.**
- More rainfall may wash more sediment and pollutants into streams, leading to **lower water quality** and altering coastal water characteristics.
- Warmer temperatures may **increase the frequency of harmful algal blooms**.

Geohazards

Geologically hazardous areas or "geohazards" are areas more likely to experience erosion, landslides, earthquakes, or other geological events that threaten human health and safety. As such, these areas are not well suited for development.

In Shoreline, known landslide areas are present along the downstream end of Boeing Creek, along the shoreline, and in steep areas along the eastern edge of the city. Steep slopes and landslide hazard areas could experience changes in stability as seasonal rainfall patterns change over time, particularly during the winter when rainfall totals increase.

PARKS AND OPEN SPACE

Moderate vulnerability because higher temperatures will stress natural systems in parks and open spaces, but many City parks are irrigated, making them better able to withstand the increased stress.

What are urban heat islands?

Areas where roofs, pavement, and other dark-colored hard surfaces absorb heat, causing some areas of a city to be warmer compared to shaded or vegetated areas (like forested parks) or surrounding rural landscapes. Urban heat islands already exist in Shoreline and many other cities. As temperatures rise with climate change, people, plants, animals, and infrastructure in urban heat islands may become more vulnerable.

Parks provide opportunities for climate change resilience by soaking up rainwater and providing shade. However, park facilities and natural features will face pressure from rising temperatures and changes in rainfall, combined with a growing population. Rising temperatures and longer summer droughts may also stress plants in open spaces, potentially leading to plant die-offs and increased fire risk.

Recreational parks with hard surfaces—parking lots, tennis courts, and playfields—already contribute to localized urban heat islands that may increase risk of heat exposure for park users, especially more vulnerable groups like children and older residents. However, the plants and green spaces in parks can help offset some of the heat impacts.

URBAN TREES

Moderate vulnerability because warmer temperatures and emerging pests pose risks to tree health, but irrigation makes them more resilient to these impacts.

Vulnerable Tree Species

Shoreline is home to many valued native tree species, including madrone, bigleaf maple, western red cedar, Douglas-fir, and cascara. Some tree species will be more vulnerable to climate change impacts, while other trees will adapt to a wider range of environmental conditions. The City is in the process of reviewing and updating its Tree List to encourage planting of resilient, long-lived tree species to support climate change resilience. The City can update this list as conditions change.

Urban trees provide many important services that will strengthen Shoreline communities against the negative impacts of climate change. For example:

- Tree canopy provides **shade** and reduces **urban heat island** effects.
- Trees **soak up rainwater runoff** during intense storms, reducing the burden on stormwater pipes. A typical street tree can soak up to 760 gallons of rainwater in a year.
- Trees and other green spaces can **reduce stress levels**, providing mental health benefits to residents.

While large patches of forest are still present in Shoreline, large stretches of paved area within the city contribute to urban heat islands. As the city continues to grow, trees may be removed in some areas to make way for development, potentially worsening the urban heat island effect as well as surface water management challenges in those areas. However, current City regulations help to protect the existing tree canopy by requiring retention of larger trees, as well as replacement for trees that are removed.

Pests and diseases that weaken trees may become more prevalent with warmer temperatures. Trees weakened by pests and diseases are more likely to struggle in hotter, drier summers.

WHAT IS SHORELINE DOING?

- **Green Cities Partnership:** this coalition of cities and counties in Puget Sound is committed to preserving urban forests. As a member of this partnership since 2019, Shoreline has already restored almost two acres of degraded urban forest and installed over 2,500 native shrubs and trees.
- **Ballinger Open Space Restoration:** the City partnered with the Mountains-to-Sound Greenway Trust to use urban carbon credits to fund forest restoration at the Ballinger Open Space, replacing three acres of invasive plants with 2,000 native trees.
- **Urban Forest Strategic Plan:** the City's 2014 plan includes a priority of achieving a "climate appropriate degree of tree cover, community-wide." Current tree canopy is protected through City code regulating tree removal.

Additional strategies that Shoreline is planning or could pursue to build climate resilience include:

- **Increasing connectivity between open spaces** to improve species resilience, plant regeneration opportunities, and enhanced recreational opportunities.
- **Planting native species** in parks, lawns, and the right-of-way to upgrade these underutilized spaces, help reduce flooding and erosion, expand urban habitat, and enhance natural spaces for Shoreline residents. Planting trees in open spaces and portions of parking lots can also expand tree canopy cover, and combat heat island effects.
- Modifying the City's plant palettes to **use more drought-tolerant plants** that can withstand increased heat and less rainfall during the summer.
- Using the City's **Parks, Recreation, and Open Spaces Plan** to identify additional ways to build climate resilience.

BUILT ENVIRONMENT

VULNERABILITY TO CLIMATE CHANGE

Warmer temperatures and more extreme rain events may impact Shoreline's built environment as the city grows. Green building and infrastructure can help keep the city cool and soak up water.

Shoreline communities are likely to face the following impacts of a changing climate:

Buildings & Development
HIGH VULNERABILITY
Hotter temperatures and heavier rainstorms can increase risk of extreme heat and flooding in developed areas.

Housing
MODERATE VULNERABILITY
More extreme heat can raise the cost of energy to keep homes cool. Flooding and sea level rise threaten homes in some areas.

Transportation
LOW VULNERABILITY
More intense rainstorms may interrupt transit service and extreme heat could weaken infrastructure.


Solar panels at City Hall

BUILDINGS AND DEVELOPMENT

High vulnerability due to the need to prevent impacts of higher temperatures and increased flooding risk in the context of redevelopment and a growing population.

Between 2000 and 2018, Shoreline's population grew by 7 percent and is expected to keep growing to surpass 68,000 residents by 2035. Shoreline's population is aging as the baby boomer population retires. There has also been a shift toward smaller households. These population changes signal the need for higher-density housing and development to accommodate projected growth. High-density development can increase vulnerability to some climate change impacts. For example:

- As air temperatures get warmer in the future, roads, sidewalks, roofs, and other **hard surfaces absorb heat**, making it feel even hotter compared to areas with green space.
- Rainstorms are projected to become more intense and frequent in the future. **Hard surfaces increase flooding risk** because they prevent water from soaking into the ground and eventually into Puget Sound.

As Shoreline's community continues to grow, a transition from single-family homes—with lawns, trees, gardens, and landscaping—to denser housing developments with relatively less green space has the potential to exacerbate heat impacts. This transition may be most significant in areas currently developed at 40 percent or less of their zoned capacity.

However, high-density development and transit-oriented development (TOD) can also help reduce carbon emissions and vulnerability to climate change impacts. With sustainable and low-impact techniques, high-density development can help reduce energy use, mitigate urban heat island effects with features like green roofs, and mitigate flooding risks with features like rain gardens and bioswales. In addition, TOD improves efficiency and access to transit and services by centering development in multi-use areas that are walkable, bikeable, and near major transit systems.

HOUSING

Moderate vulnerability due to the need to reduce impact of extreme heat, flooding, and sea level rise while also keeping housing affordable.

TEMPERATURE CHANGES AND ENERGY DEMAND

Temperatures in the Puget Sound region are projected to get warmer, with summertime daily highs around 85°F by the 2050s. Pavement, sidewalks, and other hard, dark-colored surfaces absorb heat and make the air feel even hotter in urban places, called "urban heat islands."

Extreme heat increases the need for air conditioning (A/C) during the summer to keep homes and indoor spaces cool, which will likely increase energy use and associated costs for energy users. Lower-income populations have fewer resources to pay for A/C units and higher energy bills, making them more vulnerable to warmer temperatures.

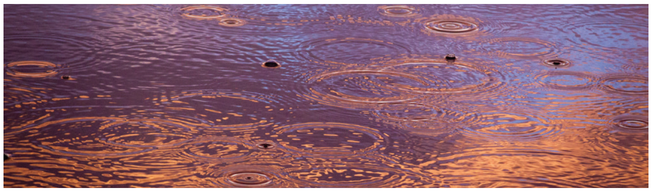
Winter temperatures in the Puget Sound region are projected to increase as well, with nighttime minimums increasing by approximately 5.4°F by the 2050s. Warmer winter temperatures may reduce heating costs for homes and indoor spaces, which may partially offset the impact of increased summer cooling costs.

Many of Shoreline's buildings and utilities are aging, with nearly 58 percent of Shoreline's housing stock being 50+ years old. Retrofitting homes, buildings, and infrastructure can help reduce vulnerability to impacts and mitigate rising energy costs.

Housing Affordability

Consistent and readily available housing can provide residents with the stability needed to respond and adapt to climate change impacts. The average Shoreline household spends 29 percent of their income on housing costs, which is roughly consistent with the regional and national average.

Households with lower incomes may spend over a third of their income on housing—leaving them with fewer resources to install and use A/C units, find alternative modes of transportation if streets are flooded, or take other steps to be more resilient.



HEAVIER RAINS AND FLOODING CONCERNS

Precipitation during the fall, winter, and spring is projected to increase in the Puget Sound region with climate change. Heavy rain storms will become more severe and more frequent. These extreme rain storms will increase the risk of flooding in low-lying areas. Homeowners and property owners in these areas may have additional costs to repair damages or modify their properties to be more resilient. Residents in these areas may face difficulties getting around if sidewalks and streets are flooded.

SEA LEVEL RISE

Shoreline is projected to experience between 2.0 feet and 2.5 feet of sea level rise by 2100 compared to 1991-2009. Sea level rise can increase coastal erosion and flooding, especially due to surges of water during extreme storms and high tides. Since most of Shoreline is protected from these impacts by the railroad, sea level rise and storm surge is expected to affect only a small number of households.

TRANSPORTATION

Low vulnerability due to multiple transportation options available to residents and the resilience of major transportation routes.

Higher temperatures, changes in precipitation, and extreme rain events are expected to impact transportation systems. For example:

- **Heavier rain events may cause more flooding and damage** to Shoreline's transportation infrastructure. Heavy rainfall can erode soil that support roads, bridges, and tunnels, and can disrupt evacuation or emergency service routes.
- **Warmer temperatures may cause pavement and rail tracks to soften, expand, and buckle**, cracking and damaging roads and sidewalks and posing a risk of train derailment.

Waterfront Railway at Innis Arden Reserve Park

These climate change impacts may place stress on transportation infastructure and interrupt transit services. As a result, people may have reduced access to healthcare, emergency services, food, and workplaces.

Climate change impacts may also make mobility more difficult for residents with accessibility needs (e.g., people who use wheelchairs) and residents who rely on transit, walk, or bike. While 18 percent of Shoreline residents use transit, walk, or bike to work, 95 percent own at least one car, indicating that most residents have more than one option in case of transportation disruptions. Multiple options for getting around, including public transit support for people with accessibility needs, enhance resiliency for all users in the transportation system. Link Light Rail expansion will provide even more transit options for Shoreline residents in the future.

WHAT IS SHORELINE DOING?

- **Deep Green Incentive Program:** provides incentives to residents and developers to implement energy and water conservation practices and other green building practices that go above and beyond what is required by code.
- **Green Building Requirements:** new development in areas surrounding future light rail stations are required to meet specific levels of green building certification.
- **Complete Streets Ordinance:** requires all City roads enable safe and convenient access and travel for all types of users including pedestrians, bicyclists, and transit riders.

Additional strategies that Shoreline is planning or could pursue to build climate resilience include:

- Working with local utility companies to **promote energy efficiency incentives and programs** to improve insulation and weatherization of buildings.
- **Enhancing tree canopy in developed areas** to naturally lower indoor temperatures by providing valuable shade and mitigating the urban heat island effect.
- **Encouraging the use of white or green roofs** to reflect heat and reduce the need for cooling, especially in more developed areas in Shoreline.

PUBLIC HEALTH, SAFETY & EMERGENCY SERVICES

VULNERABILITY TO CLIMATE CHANGE

Rising air temperatures, more extreme heat waves, and increased wildfire risk across the state may increase risk of heat-related illnesses and reduce air quality, impacting the physical and mental health of Shoreline residents. Emergency services may be more in demand due to these impacts.

Shoreline communities are likely to face the following impacts of a changing climate:

Heat-related Illnesses
HIGH VULNERABILITY
More extreme temperatures may increase risk of heat-related illnesses, especially in areas with more paved surfaces that absorb heat.

Air Quality
HIGH VULNERABILITY
Warmer temperatures and higher risk of wildfire smoke may cause more pollution and reduce air quality.

Mental Health Stress
MODERATE VULNERABILITY
Climate change impacts may increase anxiety, depression, and other mental health stress for all populations.

Emergency Services
LOW VULNERABILITY
More demand for emergency services due to public health and safety risks.

Vector-borne Diseases
LOW VULNERABILITY
More rainfall and warmer temperatures may increase vector populations.


Interurban Trail

People and Climate Change

Climate change will affect different people in different ways. Some people may feel ill because of higher heat, have trouble breathing because of poor air quality, or worry about the future. For example:

- Children, older adults, and people with chronic medical conditions may be **more sensitive to climate change impacts**.
- People working or living outdoors, like construction crew, landscapers, or people experiencing homelessness, are **more exposed to extreme weather, like high heat**.
- People who have fewer resources, like low-income households and people without health insurance, may have a **harder time preparing for the impacts of climate change**.

It's important to look out for our neighbors and work together to make sure our community is healthy and safe.

HEAT RELATED ILLNESSES

High vulnerability due to the need for resources to protect residents from exposure to extreme heat.

Increasing summertime temperatures and high heat days are expected to increase the risk of heat-related illnesses, and potentially death, in the Puget Sound region. Between 1980-2010, high-heat days caused a 10 percent increase in risk of death for all ages in King County, with a higher risk for people age 65 and older.

Heat waves in the Puget Sound region are expected to become more frequent and more severe, with the hottest days of the year projected to be 6.5°F warmer by the mid-21st century compared to the 1970-1999 average. The coolest nights are projected to be 5.4°F warmer by mid-century, indicating less relief from daytime heat and more risk of heat-related illnesses.

URBAN HEAT ISLANDS

In Shoreline, most urban heat islands occur at schools and commercial centers like Shoreline Place where parking lots and large roofs absorb heat and fewer trees are present to reflect heat and provide shade.

Children may be more exposed to heat stress at schools where many urban heat islands are located. Because this population is more sensitive to heat stress, they may be more vulnerable to increasing temperatures from climate change.

As Shoreline's community continues to grow, a transition from single-family homes—with lawns, trees, gardens, and landscaping—to denser housing developments with relatively less green space has the potential to exacerbate heat impacts. This transition may be most significant in areas currently developed at 40 percent or less of their zoned capacity.

What are urban heat islands?

Areas where roofs, pavement, and other dark-colored hard surfaces absorb heat, causing some areas of a city to be warmer compared to shaded or vegetated areas (like forested parks) or surrounding rural landscapes. Urban heat islands already exist in Shoreline and many other cities. As temperatures rise with climate change, people, plants, animals, and infrastructure in urban heat islands may be more vulnerable.

AIR QUALITY

High vulnerability due to the need for preventative measures and more treatment for people affected by allergies and wildfire smoke.

Air pollutants, such as vehicle exhaust and wildfire smoke, negatively impact outdoor air quality. Poor air quality can harm human health—especially for people who are more sensitive, such as children, people who are older, and people with existing respiratory conditions, heart conditions, or asthma. In 2018, King County experienced 11 days when ground-level ozone (an indicator of air quality) was unhealthy for sensitive groups—a slight increase from the annual average of eight days between 2013 and 2017. Ground-level ozone increases with higher temperatures.

As the climate changes, warmer temperatures are expected to reduce air quality, especially during summer months, posing a greater risk of asthma, bronchitis, heart attacks, and premature death. By mid-21st century in the Greater Seattle area, there may be nearly twice as many deaths per year from ozone compared to the 1997-2006 average.

WILDFIRE SMOKE

Wildfire smoke has worsened local air quality in recent years. In 2017 and 2018, the Seattle area had 24 days of increased air pollution due to wildfire smoke, with several days during both years considered unhealthy for all populations. As climate change is expected to increase the risk of wildfire in Washington, Shoreline may experience more days when wildfire smoke reduces air quality in the future.

ALLERGIES

Warmer seasonal temperatures and fewer days with frost are expected to lengthen the pollen season. More carbon dioxide in the atmosphere has allowed plants to produce more pollen, making the pollen season more severe. These impacts could worsen allergy symptoms and may contribute to more asthma attacks.

INDOOR AIR QUALITY

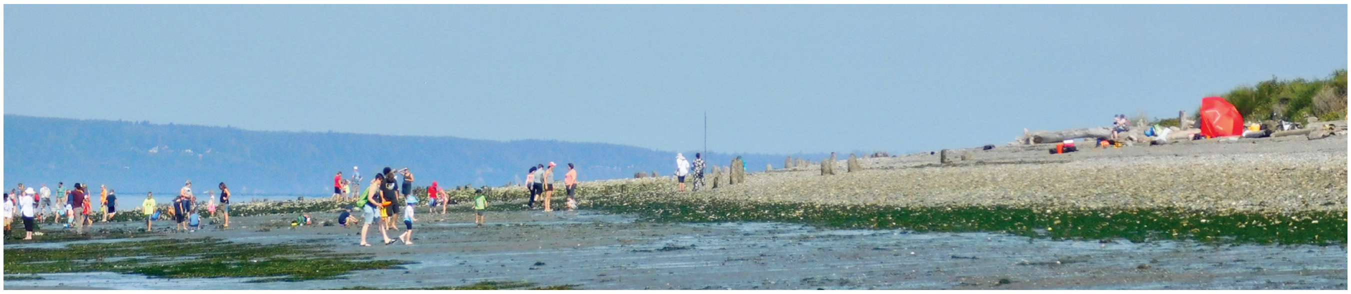
Increased amounts of ground-level ozone due to higher temperatures can worsen indoor air quality as ozone enters buildings through windows, doors, cracks, and other openings. More extreme rainfall during the fall, winter, and spring—along with warmer temperatures—may cause more mold growth indoors. Worse indoor air quality may be especially stressful on residents' health when outdoor air quality conditions are also poor, like during the summer.

MENTAL HEALTH STRESS

Moderate vulnerability due to a potential increase in mental health stress and anxiety associated with the impacts of climate change.

Increased exposure to climate change impacts may directly and indirectly worsen mental health illnesses and anxiety-related conditions. According to a 2017 American Psychological Association report, climate change can affect mental health due to trauma from extreme weather as well as emotions like fear, powerlessness, and anger related to the long-term changes in climate.

- Experiences with an extreme weather event or natural disaster can cause **post-traumatic stress disorder**.
- Uncertainty about future conditions, feelings of losing control over a situation can lead to **anxiety and depression**.
- Indigenous communities in particular may experience **grief**, depression, and anxiety from loss of culturally important resources, traditions, or sites.



EMERGENCY SERVICES

Low vulnerability due to adequate capacity of service providers to respond to higher demand for emergency response from extreme events.

As climate change impacts increase risks to public health and safety, demand for emergency medical services in Shoreline may increase. Local researchers found that high-heat days in King County increased the risk of calls for emergency medical services among people of all ages, including working-aged people between 15 and 64 (a group that is generally considered relatively resilient to health risks).

Heavier winter precipitation can increase the risk of flooding, landslides, and other natural hazards, which may also increase demand for emergency response services. However, these events may also make it more difficult for service providers to reach people in need, especially if flooding covers major thoroughfares and arterial roads. Fortunately, medical services are relatively accessible to Shoreline residents, with several urgent care clinics located in the Aurora Avenue corridor and emergency rooms located about four miles away in Edmonds and Northgate.

VECTOR-BORNE DISEASES

Low vulnerability due to capacity to treat and prevent the current low prevalence of diseases from mosquitoes and other vectors, even if they become more common.

Vectors are organisms like mosquitoes, ticks, flies, and fleas that can transmit infectious diseases between humans or from animals to humans. **Vector-borne diseases** are human illnesses caused by parasites, viruses, and bacteria that are transmitted by vectors. Lyme disease and West Nile Virus are among the vector-borne diseases that have been observed in Washington.

Warmer temperatures may increase populations of vectors and can expand the area where vectors are able to survive—and therefore, where diseases are found. Given that the current prevalence of vector-borne diseases in Shoreline is relatively low, and there are no specific projections that it will increase in the future, vector-borne diseases represent a lower source of climate vulnerability for Shoreline.

WHAT IS SHORELINE DOING?

- In 2019, the City prepared an updated Hazard Mitigation Plan Annex to identify risks and vulnerabilities from severe weather, floods, wildfire, and other hazards, as well as comprehensive mitigation strategies.

Additional strategies that Shoreline is planning or could pursue to build resilience include:

- **Establishing cooling centers** for communities to use during extreme heat events. Locate the cooling centers in places that are easily accessible for vulnerable populations.
- **Prioritizing future tree plantings** in urban heat islands.
- Using the City's new **climate impacts mapping tool** to assess potential vulnerabilites for City projects and explore ways to build equitable climate resilience.
- Developing **guidance for public health professionals to support mental health needs** of communities and help them build psychological resilience to extreme weather and natural disasters.