EXECUTIVE SUMMARY

Tacoma Climate Change Resilience Study

ENVIRONMENTAL SERVICES DEPARTMENT
MAY 2016

City of Tacoma
WASHINGTON

Tacoma Climate Resilience Study Team

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ACKNOWLEDGEMENTS

City of Tacoma

April 26, 2016

In October of 2015, the City of Tacoma joined 484 other cities worldwide in the Compact of Mayors, the largest coalition of city leaders addressing climate change. By joining the Compact of Mayors the City of Tacoma is recognizing our commitment to reduce greenhouse gas emissions, track our progress and prepare for the impacts of climate change.

With over thirty miles of shoreline, soaring bluffs and a significant estuary at the mouth of a mighty glacier-fed river that joins Commencement Bay, Tacoma is the pearl of the Puget Sound. An uncomfortable truth is that many of our unique and treasured natural assets are threatened by climate change. Climate change threats extend to the built environment and people as well.

We are already seeing impacts of climate change, which will only get more pronounced over the coming decades. The purpose of the Climate Change Resilience Study is to help prepare the City of Tacoma to be more resilient in the face of these threats by enhancing our capacity to prevent, respond and adapt to threats posed by climate change.

Sincerely,

Marilyn Strickland
Mayor, City of Tacoma

T.C. Broadnax
City Manager

Climate-driven changes in temperature, precipitation, and sea level are projected to have wide-ranging impacts on the Puget Sound region in the coming decades.

This study marks the beginning of a process undertaken by the City of Tacoma's Environmental Services and the Planning and Development Services Departments to better understand and proactively manage climate risks in order to protect local residents, make sound investments, and ensure that the City can prosper, even in a changing climate.

Three systems were considered for this study:

1. **Built infrastructure**, with a focus on surface water, wastewater, solid waste, and transportation assets;
2. **Natural systems**, including streams, lakes, wetlands, open spaces, and restoration sites; and
3. **Social systems**, including general health and social services and potentially at-risk populations and neighborhoods.

This document summarizes the high-level findings of the study.

Sites that were assessed in more detail included the following:

- Ruston Way
- Salmon Beach slopes
- Marine View Drive
- First Creek
- Leach Creek basin
- Flett Creek basin
- Commencement Bay tideflats and shoreline
- Puyallup River delta, levees, historic channel zone, and restoration sites

TACOMA'S CLIMATE IS CHANGING

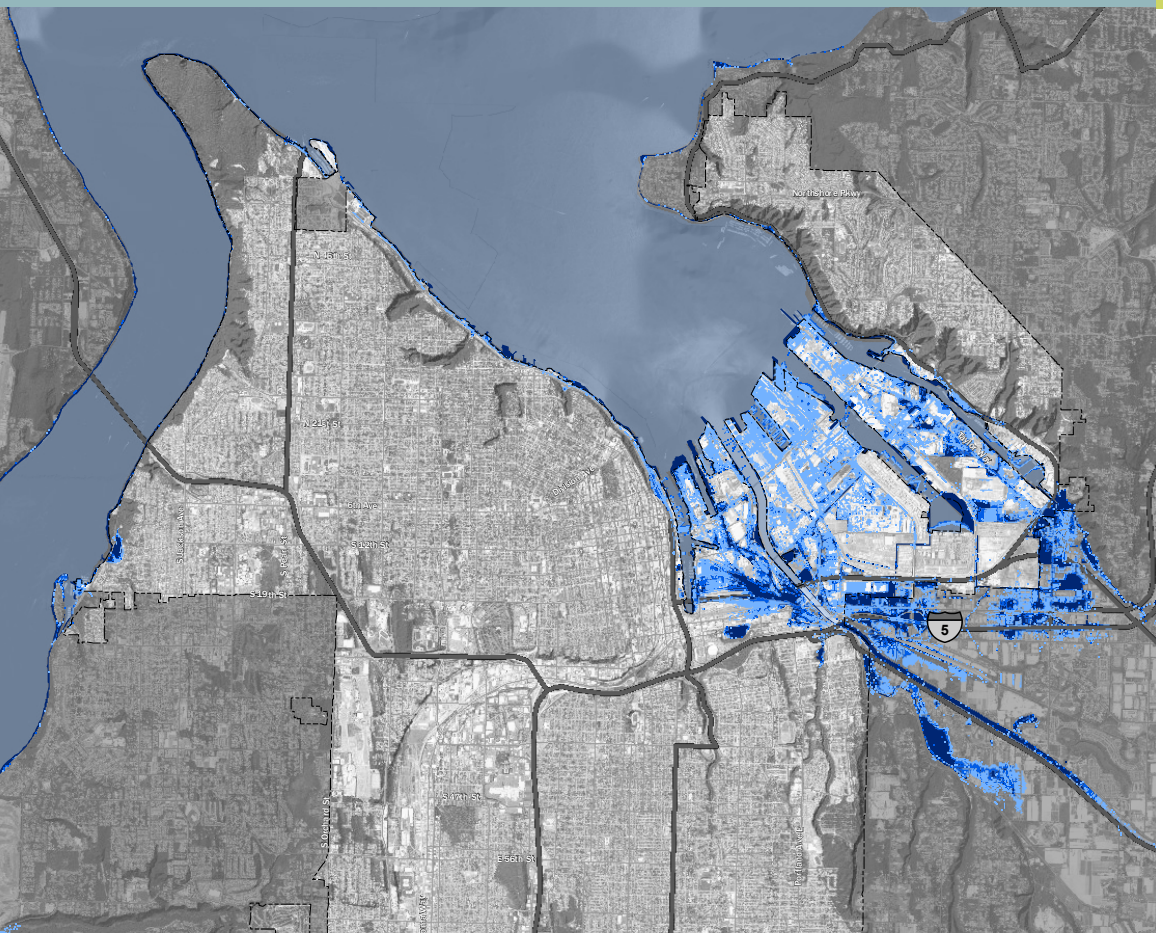
Changes in the climate have already been observed.

- **Average annual temperature increased** by 1.3°F between 1895 and 2011 across the Pacific Northwest [1] [2].
- **Nighttime heat waves have been occurring more frequently over the last century west of the Cascades.** There has been no clear trend in daytime heat waves.
- **The frost-free season in the Pacific Northwest lengthened** by 35 days (+/- 6 days) from 1895 to 2011 [1]. This translates into a longer growing season for farmers.
- **Precipitation changes are less clear.** There is some indication that extreme precipitation may have increased, but not all studies agree.
- **Snowpack in the Washington Cascades declined** from the mid-20th century to 2006, with substantial natural year-to-year variability that meant that some years still saw heavy snowpack [3] [4].
- **Peak spring streamflow has been happening earlier.** Between 1948 and 2002, the timing of peak spring streamflow shifted earlier by 0-20 days in many snowmelt-influenced rivers in the Pacific Northwest [5].
- **Mt. Rainier's glaciers have been shrinking**—cumulatively by 27 percent between 1913 and 1994.
- **Sea level has risen** by 7.8 inches over the last century.

In the absence of major reductions in greenhouse gas emissions, global and regional climate will change rapidly in the coming decades.

- **Warming is expected in all seasons, with the most warming occurring in the summer.** Depending on the emissions scenario, we can anticipate an average increase in average annual temperature of 4.0°F to 5.3°F by the 2050s, compared to 1970-1999 [6].
- **Tacoma is likely to see more intense heat waves** as maximum temperatures rise [7].
- **Climate models do not project significant changes in total annual precipitation** for the Pacific Northwest. However, more of that precipitation could fall in extreme events such as those generated by atmospheric rivers.
- **More precipitation will fall as rain, and snow will melt earlier in the spring.** Overall, this means a shorter snow season and earlier peak streamflow timing. Snowpack will continue to decline.
- **Flood risk in the Puyallup watershed is expected to increase** along with the anticipated increase in heavy precipitation events. Increasing sedimentation in local rivers—which are no longer dredged—will further contribute to flood risk.

TACOMA'S CLIMATE IS CHANGING



This image of the City of Tacoma illustrates the area that could be exposed to flooding during extreme high tides based on sea level rise projections for 2050, using the high end of the estimate range (19 inches). Darker areas are already below current extreme high tide elevations. Note: The shaded areas are based on elevation and are not necessarily all hydraulically connected to marine areas; more detailed mapping is required to determine actual areas of marine flooding under current and future extreme high tides.

- **Landslides are expected to become a more common occurrence** along with more heavy precipitation events, particularly in areas most prone to present-day landslides.
- **In Washington State, sea levels are projected to increase by -1 to 19 inches by 2050 and by 4 to 56 inches by 2100, relative to 2000 levels** [8]. With 24 inches of sea level rise, the 100-year flood event would become an annual event [9].
- **Ocean acidity is expected to increase in Puget Sound,** leading to impacts such as increased corrosion and inhibited shellfish development.
- **It is important to note that natural variability tends to be the dominant factor behind shorter-term (yearly to decadal) fluctuations in temperature and precipitation.** While average temperature is going up, for example, we will continue to see warmer-than-average years as well as colder-than-average years. Climate change is more relevant over longer time frames.

Please refer to the full report for more details and sources for the information presented above.

HOW WILL A CHANGING CLIMATE AFFECT OUR CITY?

Built environment

Wastewater system

- **Large portions of the wastewater system in the tideflats are below the existing Base Flood Elevation and several feet below projected future extreme high tides [10].** If system modifications are not made, these components could be affected by saltwater intrusion or damaged during extreme high tides. Saltwater could also corrode metal parts within the wastewater treatment plant.
- **Because the City of Tacoma no longer has a combined stormwater-wastewater system, there is relatively low risk from more extreme rain storms,** although stormwater can still flow into the wastewater system through leaks. Sensitivity to the higher flow rates will be greatest where the wastewater system is already under capacity or where system condition is poor.

Surface water system

- **The surface water system deals directly with precipitation and will therefore be directly affected by more frequent and intense precipitation events as the climate changes.** The impacts will be greatest where there are more impervious surfaces—such as in the tideflats, Foss Waterway, Leach Creek, and Flett Creek watersheds.
- As with the wastewater system, vulnerability is highest where the stormwater system is already overburdened or where system condition is poor.

Transportation

- **The City of Tacoma has several roads along the shoreline and in the tideflats that are below projected 2050 extreme high tides and several feet below projected 2100 extreme high tides.**
- In most cases, coastal flooding associated with high tide events is not expected to cause widespread damage to road and rail infrastructure, but it would disrupt transit, particularly in the tideflats area.

Table 1. Summary of infrastructure vulnerability assessment results

System	Vulnerability		
	High	**Medium**	**Low**
Wastewater	• Central Wastewater Treatment Plant • Pump stations	• North End Wastewater Treatment Plant • Conveyances • Overflow points (surface water cross-connections)	• Western Slopes Wastewater Treatment Plant • Gravity conveyances in the tideflats and shoreline area
Surface water	• Conveyances that are already under capacity • Culverts and small bridges	• Conveyances in landslide-prone areas • Street trees and plants	• Pump stations and holding basins
Transportation	• Ruston Way • Marine View Drive • Tideflats • Roads within the Puyallup River delta floodplain	• Roads near landslide-prone areas • Dock Street • Street trees	• Pavement
Solid Waste			• Tacoma landfill

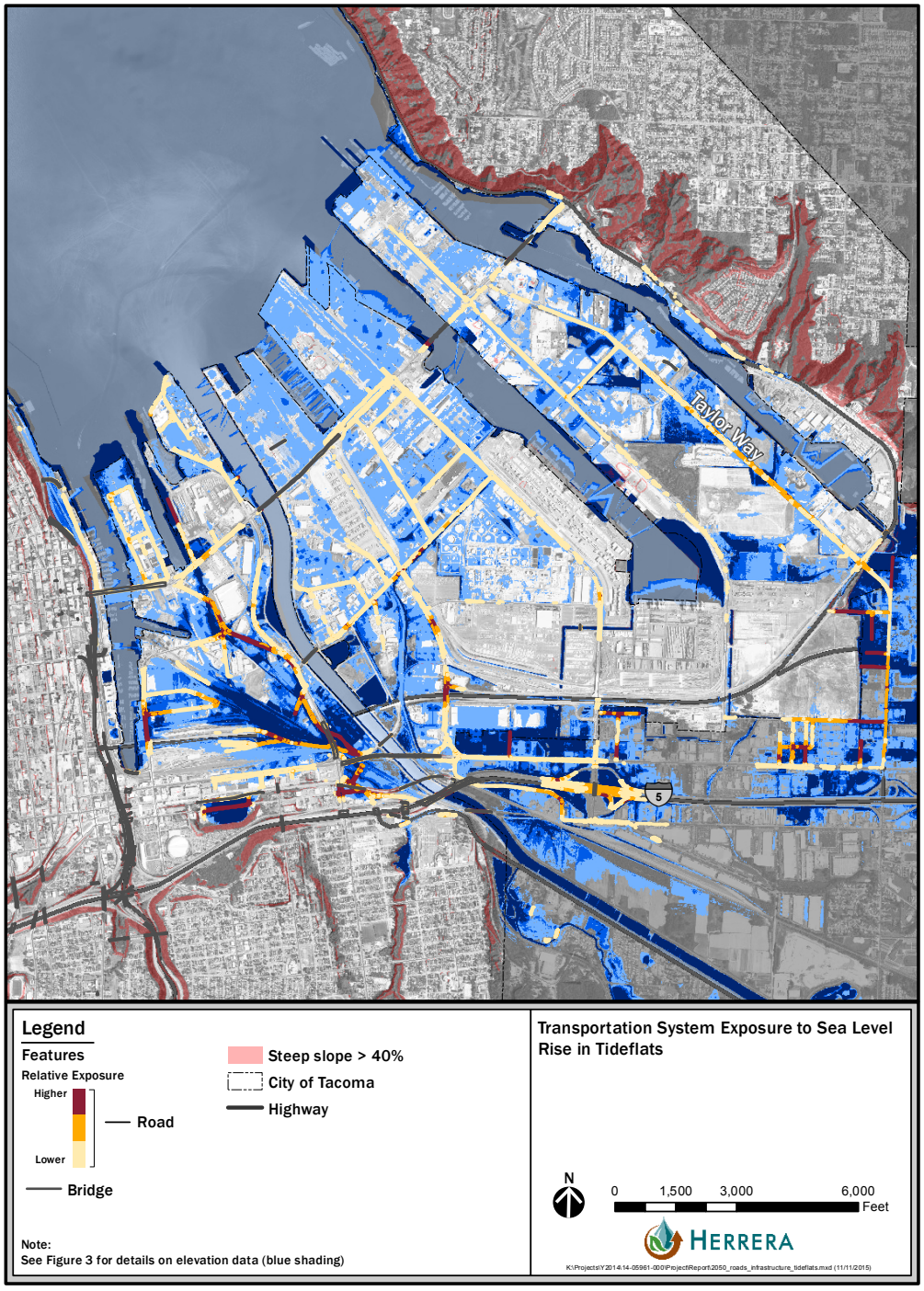
The assessment of built infrastructure vulnerability focused on four systems.

SURFACE WATER SYSTEMS
including gravity conveyance pipes, streams and other open channel conveyances, major holding basins, and pump stations.

WASTEWATER SYSTEMS
including gravity conveyance pipes, pump stations, force mains, and treatment plants.

TRANSPORTATION SYSTEMS
including city-owned streets and bridges as well as state routes that lie within the study focus areas.

SOLID WASTE SYSTEMS
including the closed Tacoma Landfill.



Projected tideflats road exposure to extreme high tides associated with sea level rise to 2050 using a high emissions scenario. Sections of roadway that are particularly vulnerable to flooding in the coming decades are highlighted in red and orange.

RECOMMENDATIONS:

Built Environment

Some of the near-term needs identified by the study include the following:

1. **Ensure that capital improvement projects consider climate change risks.** Develop a city standard of practice that accounts for climate change impacts in design of capital projects.

2. **Gather additional data on existing infrastructure problems that will be exacerbated by climate change impacts like sea level rise.** For example, develop a list of existing capacity-related surface water problems for the whole city and existing challenges along the shoreline. Conduct more detailed site-by-site evaluations of exposure to landslide risks, focusing on most critical roads, infrastructure, and vulnerable populations.

3. **Identify wastewater and stormwater system components—such as manholes, pump stations, and treatment plants—that may be put at risk by sea level rise, marine flooding, and related corrosion, and adjust system components accordingly.** For example, install gasketted and bolted manhole lids, and raise the elevation of weirs at vulnerable wastewater-stormwater cross connections (wastewater overflow points).

Additional recommendations can be found in the full report.

The City of Tacoma has 33.6 miles of marine shoreline in Puget Sound and Commencement Bay. Tacoma also intersects with the final reaches of the Puyallup River, which drains over 1,065 square miles. Many of the city's natural systems have been altered as a result of urbanization. Most notably, development within the tideflats has removed around 98 percent of the former intertidal wetland areas. Paved areas and other urban land covers generate surface runoff that is routed through local lakes, wetlands, and streams.

Natural systems

Shorelines, beaches, and tidal wetlands

- **Marine shorelines that have natural bluff-backed beaches—like those at Point Defiance—will be more resilient** because they can migrate back as sea levels rise.
- **Where infrastructure development and shoreline armoring are in place—like along Ruston Way and many other parts of Tacoma's shoreline—beaches and habitats will not be able to migrate** with the changing sea level.
- **Tidal wetlands are relatively rare in Commencement Bay now, and they are highly vulnerable to changes in sea level.** If sea level rise occurs quickly, or there isn't available space for them to migrate, tidal wetlands are likely to become unvegetated mudflats.

Tributary streams

- **Tributary streams, which drain the majority of Tacoma's surface area, will be affected by increases in heavy rainfall and winter runoff.** These changes will bring in more pollutants from urbanized areas.
- **First Creek, which flows through highly erodible glacial sediments, will be more sensitive.** Some streams have engineering structures to channel high flows away; these are less sensitive to heavy rainfall.

Freshwater wetlands

- **Wetlands supported primarily by groundwater will be minimally affected by warmer temperatures and summer droughts.** Tacoma's larger systems (Tacoma Community College and China Lake) appear to be groundwater-supported. Wetlands dominated by surface water will be more affected.

Open spaces

- Open spaces are natural or landscaped areas that provide community space, habitat for plants and animals, and recreational opportunities.
- **Temperature increases and changes in seasonal precipitation patterns could affect open spaces,** particularly if they are newly planted, recently established, or on small patches of land within developed areas.
- **Established natural areas with a diverse range of plant species, like Point Defiance Park, will be much less impacted by changes in the climate.**

Aquifer recharge areas

- **Because overall annual precipitation is likely to remain similar to what Tacoma has experienced in the past, adequate recharge of the local aquifer—which is primarily located in the South Tacoma area—is not expected to be a challenge.** While this aquifer provides as much as 40 percent of the City's drinking water in the summer, it is still the secondary source of drinking water after the Green River watershed [11].

Wapato Lake

- As the climate changes, additional pollutant loading from peak storm events and higher summer temperatures are likely to make existing water quality issues in Wapato Lake even worse.

RECOMMENDATIONS:
Natural Systems

Some of the near-term needs identified by the study include the following:

1. **Preserve remaining natural areas, and provide more explicit design guidance or performance specifications on considering climate science in habitat restoration plans.** Greater resilience can be built into habitat restoration projects and open spaces by planning for transition zones, increasing plant diversity, extending establishment periods, and adding more habitat types.

2. **Reduce non-climate stressors (e.g., vegetation clearing, stormwater runoff, and impaired water quality) affecting fish, wildlife, plants, and ecosystems.** This will put them in a position to face other stressors—including climate change impacts—with a higher baseline level of resilience.

3. **Evaluate development surrounding steep slopes** to ensure that development practices do not either put people or property at risk of harm or disconnect a vital sediment source from the nearshore. Extend development restrictions and/or setbacks in these areas to provide additional protection from future climate-related risks.

4. **Preserve and expand urban forest canopies; complement these efforts with leaf pickup programs as needed.** Expanding forest canopies can reduce stormwater runoff, lower urban heat, and provide valuable habitat.

The restored Tahoma Salt marsh is an example of a site that is vulnerable to sea level rise; it has limited capacity to move because it is hemmed in by roads (Photo credit: Ecology Oblique Aerials)

Table 2. Relative climate vulnerability of natural systems in Tacoma

Natural Systems with **Greater** Vulnerability	Natural Systems with **Lesser** Vulnerability
Marine ecosystems	Freshwater wetlands
Puyallup River	Critical Aquifer Recharge Areas
First Creek	Most tributary streams with bypass systems
Wapato Lake	Open spaces

Tacoma has a population of just over 200,000—nearly 4,000 people per square mile.

In Tacoma, like in other communities, residents' ability to cope with and respond to climate change risks will depend on many factors, including income, social connectivity, and access to support services. City services related to emergency management, public health, and social services also play a critical role in ensuring community resilience and preparedness.

This study assessed the vulnerabilities of social systems at the census-block level, in order to identify neighborhoods and "hot spots" of greatest vulnerability to projected flooding, extreme heat, sea level rise, and landslides.

Social Systems

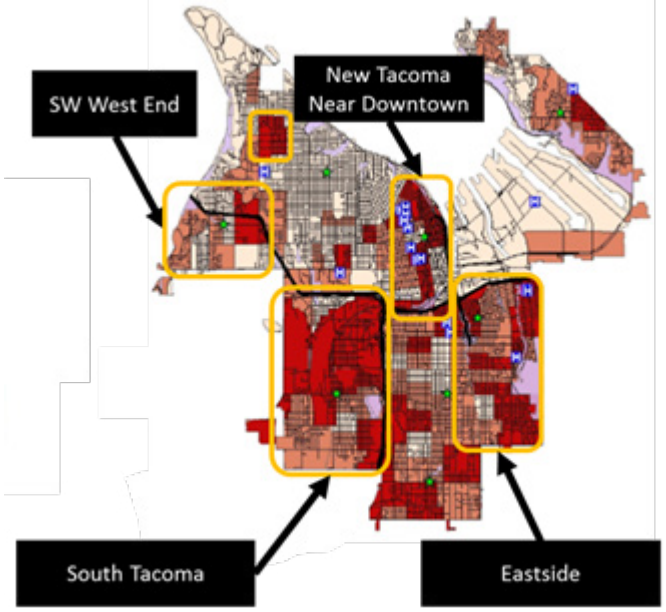
Findings

- **Populations along the city's coastlines, such as West End and North End residents and businesses, will experience higher flood risk and higher landslide risk than inland communities.** South Tacoma and the port area of New Tacoma are also at higher risk.
- **However, Tacoma's residential areas are mostly located inland. Therefore, the most prominent climate hazards for Tacoma's social systems and population centers are extreme heat and inland flooding.**
- **Future increases in the frequency and duration of extreme heat events will disproportionately affect populations located in urban heat islands and in areas with low tree canopy cover.** Areas that are most exposed include New Tacoma and the central part of the city. Only about 19 percent of Tacoma's land area is covered by trees, leaving a very large area exposed to extreme heat events. The City aims to increase canopy cover to 30 percent by 2030.
- **Potential direct inundation of the tideflats area could also carry considerable consequences for Tacoma's economy.** Tacoma has the seventh busiest container-handling port in the United States [12]. Tacoma is also an important rail shipping hub. Dependable operation of these systems in a changing climate will be critical to enable Tacoma's economy to thrive.
- Populations with especially high sensitivity to climate impacts include the sick, disabled, young, elderly, and those who work outdoors or lack access to cooling or shelter. **Relatively more of the very young and elderly reside in the West End and North East areas of the city.** These areas of the city also have relatively fewer medical facilities than other areas such as New Tacoma.
- **Persons without air conditioning at their homes or workplaces will be especially sensitive to extreme heat events.** Identified cooling centers in Tacoma include public libraries and the Tacoma Mall. Libraries are relatively equally distributed across the city, although they have limited hours of operation.
- **A person's income, level of education, first language, and level of insurance coverage will affect their ability to rebuild, retreat, or respond to extreme events and stresses.** Areas with higher concentrations of low-income households include New Tacoma, South Tacoma, and the Eastside.

RECOMMENDATIONS:

Social Systems

The results indicated that particular focus should be placed on extreme heat preparedness and resilience in South Tacoma, New Tacoma (near downtown), the southwest area of West End, and Eastside.



Some of the near-term needs identified by the study include the following:

1. **Prioritize South Tacoma, New Tacoma near downtown, the southwest area of West End, and Eastside in capital improvement, development, and planning activities as relevant** to ensure that these communities receive the services they need to adequately build resilience to climate change and other stressors.

2. **Develop a coordinated strategy for addressing extreme heat risks,** which could include actions such as enhanced public education and outreach around heat risks and preparedness; increased use of passive and active cooling solutions; and coordinated preparedness and response efforts. Maintain and expand utility rebate programs for cooling equipment, especially for lower-income households.

3. **Begin a conversation with the business community around climate impacts and resilience,** starting with forums such as chambers of commerce and business district meetings.

4. **Engage with and support community organizations that enhance community resilience** in order to understand and respond directly to needs on the ground.

Additional recommendations can be found in the full report.

[1] A. K. Snover, G. S. Mauger, L. C. Whitely Binder, M. Krosby and I. Tohver, "Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers," Climate Impacts Group, University of Washington, Seattle, 2013.

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[5] I. T. Stewart, D. R. Cayan and M. D. Dettinger, "Changes toward earlier streamflow timing across western North America," J. Climate, pp. 18:1136-1155, 2005.

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[7] Northwest Climate Science Center, "Integrated Scenarios of the Future Northwest Climate," 2014. [Online]. Available: https://www.nwclimatescience.org node/231.

[8] National Research Council, "Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future," The National Academies Press, Washington, DC, 2012.

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