

# Chapter 4.5

## Sea Level Rise Hazard Risk Assessment

### Introduction

Scientists project that the Puget Sound region will experience sea level rise throughout the 21st century. These changes will impact communities and the natural environment in profound ways.

The rise in global mean temperatures from human influenced climate change is increasing ocean thermal expansion and the rate of glacial melting – the primary drivers of sea level rise. Low lying coastal communities are most at risk. Coastal flooding is expected to become about 10 times more common and will impact the estimated 10 million Americans who live in areas prone to coastal flood hazards.<sup>1</sup> Sea level rise will cause shoreline erosion, pose challenges for transportation, damage infrastructure, and endanger public health. Hazard mitigation planning for sea level rise is critical to protect public safety, community assets, and to sustain the region’s overall livability and economic vitality. To this end,

the City of Olympia, Port of Olympia, and the LOTT Clean Water Alliance have formed a partnership and developed an Olympia Sea Level Rise Response Plan in 2019. This response plan is a major cornerstone for assessing sea level rise vulnerabilities and adapting to and mitigating its impacts on the population, the community, and its valued assets.

### Definition

Rising sea levels and land subsidence combined with coastal flooding, storm surge, and heavy rainfall will threaten Thurston County. As sea level rises, there will be an increase in the exposure and vulnerability of the population, critical infrastructure, water and wastewater treatment, trade and economic development, and natural environment. The adverse effects from sea level rise will impact communities principally by flooding, erosion, sedimentation, saltwater intrusion, and hazardous materials release.

## Area of Impact

For the risk assessment, a six-inch sea level rise scenario was used to estimate vulnerabilities and potential losses. Higher sea level rise scenarios exist, but the project budget could not support multiple sea level rise analysis scenarios. A six-inch scenario is consistent with near-term sea level rise projections and is a useful mitigation planning scenario. The Olympia Sea Level Rise Response Plan includes higher sea level rise scenarios. The next five-year update to the hazard mitigation plan risk assessment will account for higher sea level rise scenarios.

The sea level rise inundation area data was generated using the effective Digital Flood Insurance Rate Map V-zone data. Using the inundation area boundary (see Map 4.5.1 Sea Level Rise Inundation Area), and 3-foot LiDAR digital elevation model data, depth grids were generated and integrated into the GIS-based natural hazards model, Hazus. General building stock and critical facilities were uploaded into the Hazus coastal flood model. By inputting depth data and known property replacement cost values, population exposure, building exposure, and dollar-value estimates of damage were generated to characterize a hazard risk rating.

## Communities Most Vulnerable to Sea Level Rise

Communities and neighborhoods in low lying areas, estuaries, and the inlets of Thurston County including the Nisqually River Delta will be subject to inundation. The risk assessment

GIS exposure analysis shows following communities have shorelines at risk to the six-inch sea level rise scenario:

- **Thurston County** – The entirety of the unincorporated Thurston County Puget Sound shoreline is in the sea level rise inundation area. Mud Bay and the Nisqually Delta will experience the greatest impacts.
- **City of Lacey** – approximately 3,100 feet of the north city limits of the City of Lacey near Waldron Road NE is in the inundation zone, however the shoreline is undeveloped.
- **City of Olympia** – Downtown Olympia all along Budd Inlet including the Port Peninsula, Percival Landing, portions of historic downtown, and areas around Capitol Lake will be most affected. This area is highly developed and includes critical infrastructure for the City of Olympia, Intercity Transit, the LOTT Clean Water Alliance, and Port of Olympia.
- **Griffin Fire District** – There are no district assets located in the inundation areas, however Totten Inlet and Eld Inlet shorelines are within the district’s taxing boundary and service area. Sea level rise will impact routing for emergency response.
- **Griffin School District** – There are no school district assets located in the inundation areas, however student households, the district’s service area, and school bus routes are within the inundation areas.

- **Intercity Transit** – The Downtown Olympia Transit Station and portions of its connecting routes are in the inundation area.
- **McLane Black Lake Fire District 9** – There are no district assets located in the inundation areas, however Cooper Point, Eld Inlet, Mud Bay, and Budd Inlet shorelines are within the district’s taxing boundary and service area. Sea level rise will impact routing for emergency response.
- **Olympia School District** – There are no school district assets located in the inundation areas, however student households, its service area, and school bus routes are vulnerable.
- **South Bay Fire District 8** – There are no district assets located in the inundation areas, however sea level rise will impact routing and timing for emergency response.
- **The Evergreen State College** – Over 3,000 feet of the north campus property adjoins Eld Inlet. The shoreline is undeveloped, but it is an important learning environment and popular outdoor recreation area for students and community members alike.
- **Thurston Public Utilities District** – There are no district assets located in the inundation zone, however as a countywide district, sea level rise could pose transportation issues for accessing utilities near inundation areas.

## Extent and the Effects of Climate Change

The University of Washington Climate Impacts Group (UWCIG) “State of Knowledge: Climate Change in the Puget Sound” provides an overview of projections for sea level rise conditions that will affect the Puget Sound Region and Thurston County.<sup>2</sup>

Local sea level variations are driven by global, regional, and local factors. The rate of sea level rise for the Puget Sound depends on how much global sea level rises. Regional wind patterns and rainfall for the Puget Sound region also influence sea level rise. Local land elevation changes, whether land is rising or subsiding due to geological or hydrological effects will also affect sea level rise. While most of Thurston County’s shoreline is stable, downtown Olympia is estimated to be subsiding by 2.5 millimeters (0.9 inches) per decade. A large Cascadia Subduction Zone earthquake or inland earthquake along the Seattle, Tacoma, or Nisqually fault could also result in an abrupt increase in sea level rise due to a sudden drop in land elevation. Short-term sea-level variations can also be temporarily offset or accelerated by up to a foot in the winter as a result of natural variations in climate patterns such as El Niño or La Niña.

### Observed Changes

The UWCIG documents the following observed changes in its report:

- The global average sea level rose about +8 inches from 1900-2009. During the same time the Puget Sound level rose by +8.6 inches at the Seattle tidal gauge.
- There is no evidence that there will be an increase in the frequency or severity of storm surge in the Puget Sound.
- Wave heights in the Puget Sound are driven by local winds and it is unknown how wave heights will be influenced by climate change.
- There is no conclusive evidence on changes in windspeed.

### Projected Changes

The following are projected changes for sea level rise conditions and impacts. Sea level rise will:

- Increase by +14 to +54 inches in the Puget Sound by 2100.
- Increase +11 to +38 inches globally by 2100 depending on the amount of 21<sup>st</sup> century greenhouse gas emissions.
- Have no change in wind speed or the strength of low-pressure systems affecting the Puget Sound region.
- Increase the potential for higher tidal/storm surge reach and increased coastal inundation, erosion, and flooding. Small amounts of rise can shift the risk of coastal hazards in potentially harmful ways.

- Permanently inundate some low-lying areas.
- Increase the duration, extent, and depth of flooding as rivers are unable to effectively drain to the Puget Sound.
- Increase the frequency of coastal flood events. For Olympia, +6 inches of sea level rise shifts the probability of a coastal flood event from a 1% annual chance (100-year flood) to a 5.5% annual chance (1-in-18-year flood) event.
- Increase the rate of coastal bluff erosion.

### Probabilistic Sea Level Rise Projections

The UWCIG provides model projections for Thurston County for a 50 percent likely and one percent likely (high) sea level rise scenarios. Table 4.5.1 shows relative amount of sea level rise with a 50% likelihood of occurring for future decades compared to the average sea level in 1991-2009. For example, a value of 1.0 means that there is a 50% chance that the county will experience 1.0 feet of relative sea level rise. Table 4.5.2 shows the amount of sea level rise with a one percent likelihood relative to the 1991-2009 average sea level. Table 4.5.3 shows the most likely and high-range sea level rise projections for Olympia. Olympia's projections account for local subsidence that is not conveyed in the Thurston County projections.

**Table 4.5.1 Thurston County Relative Sea Level Rise with 50% Likelihood (likely scenario)<sup>3</sup>**

	Model Mean <sup>1</sup>	Model Range (10th to 90th percentile)
1980-2009		
Historical Baseline	n/a	n/a
2030		
Higher Scenario (RCP 8.5)	0.4 feet	0.3 to 0.4 feet
Lower Scenario (RCP 4.5)	0.4 feet	0.3 to 0.4 feet
2050		
Higher Scenario (RCP 8.5)	0.8 feet	0.8 to 0.9 feet
Lower Scenario (RCP 4.5)	0.8 feet	0.7 to 0.8 feet
2100		
Higher Scenario (RCP 8.5)	2.3 feet	2.2 to 2.4 feet
Lower Scenario (RCP 4.5)	1.8 feet	to 1.9 feet

**Table 4.5.2 Thurston County Relative Sea Level Rise with 1% Likelihood (high scenario)<sup>iii</sup>**

	Model Mean <sup>1</sup>	Model Range (10th to 90th percentile)
1980-2009		
Historical Baseline	n/a	n/a
2030		
Higher Scenario (RCP 8.5)	0.7 feet	0.7 to 0.8 feet
Lower Scenario (RCP 4.5)	0.7 feet	0.7 to 0.8 feet
2050		
Higher Scenario (RCP 8.5)	1.5 feet	1.4 to 1.6 feet
Lower Scenario (RCP 4.5)	1.4 feet	1.3 to 1.5 feet
2100		
Higher Scenario (RCP 8.5)	5.1 feet	5.0 to 5.2 feet
Lower Scenario (RCP 4.5)	4.4 feet	to 4.5 feet

<sup>1</sup>Representation Concentration Pathways, or RCPs are climate model scenarios for the 21st century. RCP 4.5 — a “low” scenario that assumes greenhouse gas emissions (GHG) stabilize by mid-century and fall sharply thereafter; and RCP 8.5 — a “high” scenario that assumes substantial GHG increases until the end of the 21st century.

**Table 4.5.3 Sea Level Rise Projections for Olympia<sup>4</sup>**

Year	Most Likely (inches)	High Range (inches)
2020	3	7
2030	5-7	11-13
2040	8-10	16-18
2050	11-13	23-25
2060	15-17	30-32
2070	18-20	37-39
2080	22-25	46-49
2090	27-31	54-58
2100	32-36	64-68

## Previous Incidents

### *December 27, 2022. High tide and coastal flooding in Olympia<sup>5</sup>*

On December 27, 2022, the high tide in Budd Inlet rose to 18.40 feet at 9:25 am and was 1.77 feet over the predicted tide of 16.33 feet. The barometric pressure during the morning bottomed out at approximately 28.6, but rose at the time of the flooding. This was the worst flooding event on record for Olympia. The previous worse record was 17.99 in 1987. During the January 7, 2022, Capitol Lake flooding event, the tide rose to approximately 17.9 feet.

Because the December 27, 2022 flood event was primarily a marine tidal flooding event, it was of short duration. As usual, flooding first occurred at Sylvester Street where it was controlled by sandbags. Marine water overtopped the shoreline in several locations including along 4th Avenue between Thurston Avenue and A Avenue and between B Avenue

and Corky Avenue. Structural flooding was observed at Budd Bay Café, Capitol City Yacht Sales, Olympia Autohaus and the Row Restaurant. The storm drainage system associated with the Fiddlehead outfall was overwhelmed. Several streets were closed – 4th Avenue between Sylvester and Water Streets, Water Street between 4th Avenue and State Avenue, State Avenue between Water Street and Columbia Street.

## Probability of Occurrence

Sea level rise is occurring. The probability for sea level rise impacts for communities with assets or service areas bordering the Puget Sound is high. This includes unincorporated Thurston County, the cities of Lacey and Olympia, Griffin Fire District 13, Griffin School District, Intercity Transit, McLane Black Lake Fire District 9, Olympia School District, South Bay Fire District 8, The Evergreen State College, and Thurston Public Utilities District.

## Vulnerabilities and Impacts

### Impacts to People

Sea level rise and storm incidents can be readily forecast and sufficient warning time can be provided to affected populations to protect property and public safety in affected areas. In general, coastal flooding exacerbated by sea level rise results in the same impacts as coastal and other types of flooding. Without effective mitigation measures, sea-level rise induced coastal flooding, inundation, or landslides can damage or destroy homes making them uninhabitable. People will suffer

personal property losses and could be displaced for prolonged periods. Residential wells located in the inundation areas could become contaminated from frequent saltwater intrusion or hazardous materials from nearby industrial areas.

An estimated 375 people in unincorporated Thurston County and 114 people in Olympia reside in the six-inch sea level rise inundation area and are at risk from sea level rise hazards (Table 4.5.4).

**Table 4.5.4 Thurston County Population Residing in the Six-Inch Sea Level Rise Inundation Area**

Jurisdiction	Population	Population Exposed	% Population Exposed
Bucoda	610	0	0%
Lacey	58,180	0	0%
Olympia	56,370	114	0.2%
Rainier	2,510	0	0%
Tenino	2,030	0	0%
Tumwater	26,360	0	0%
Yelm	10,680	0	0%
Unincorporated Thurston County	143,760	375	0.3%
<b>Total Planning Area</b>	<b>300,500</b>	<b>489</b>	<b>0.2%</b>

## Impacts to Structures and Systems

Sea level rise will inundate and impact low lying roads and bridges causing damage to infrastructure. Transportation impacts are disruptive to a community's economy and overall quality of life. Delay will impact transportation across all sectors and trip purposes including personal travel, commutes to work and school, public transit, emergency services, and the movement of freight, goods, and services.

Coastal flooding and inundation could disrupt the availability of electricity, water, and communications. The long-term operations for the Port of Olympia Marine Terminal will need to adapt and mitigate the effects of sea level rise to remain a viable shipping and freight facility for the region. Other Port of Olympia properties including the cargo yard, Warehouse A, Port Plaza, and the Farmers Market are likely to be inundated and impact operations and business.

The LOTT Clean Water Alliance Budd Inlet Treatment Plant is vulnerable due to its low elevation location on the Downtown Olympia Port Peninsula. Without effective mitigation measures, coastal flooding could impact the safe operation of the facility. An overland flow of water from Budd Inlet or Capitol Lake entering the city’s combined sewer/stormwater system will overwhelm the capacity of the plant which in turn could result in the discharge of untreated hazardous sewage and further contaminate marine and freshwater bodies and other areas of the community.

There are an estimated 167 residential, 102 commercial, 3 industrial, and 4 government buildings in the region that are in the six-inch sea level rise inundation area. In total, there

are 276 buildings valued over \$40 million that are potentially at risk to sea level rise hazards (Tables 4.5.6 and 4.5.7).

There are an estimated 14 community lifeline assets located in the sea level rise inundation area (Table 4.5.8). Exposed assets include a 911 radio facility, an electric substation, wastewater facilities, the Cascade Pole site, the Olympia Family Support Center, the Olympia Center, Swantown Boatworks, and six state highway bridges.

**Table 4.5.6 Number of Structures in the Six-Inch Sea Level Rise Inundation Area**

Jurisdiction	Number of Structures in Sea Level Rise Inundation Areas							
	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Bucoda	0	0	0	0	0	0	0	0
Lacey	0	0	0	0	0	0	0	0
Olympia	33	83	3	0	0	3	0	122
Rainier	0	0	0	0	0	0	0	0
Tenino	0	0	0	0	0	0	0	0
Tumwater	0	3	0	0	0	0	0	0
Yelm	0	0	0	0	0	0	0	0
Unincorporated Thurston County	134	19	0	0	0	1	0	154
<b>Total</b>	<b>167</b>	<b>102</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>276</b>

**Table 4.5.7 Value of Structures and Contents in the Six-Inch Sea Level Rise Inundation Area**

Jurisdiction	Total Buildings	Total Residential Buildings	Total Building and Contents Value	Buildings Exposed	Total Building & Contents Exposed	% Total Value
Bucoda	245	237	\$63,726,655	0	\$0	0.0%
Lacey	18,985	17,637	\$17,357,526,547	0	\$0	0.0%
Olympia	18,242	16,257	\$19,116,213,011	122	\$556,524,151	2.9%
Rainier	875	814	\$393,003,023	0	\$0	0.0%
Tenino	751	651	\$404,778,123	0	\$0	0.0%
Tumwater	9,513	8,408	\$9,362,171,728	0	\$0	0.0%
Yelm	3,139	2,827	\$2,077,637,133	0	\$0	0.0%
Unincorporated	53,104	51,429	\$24,765,596,428	154	\$71,205,795	0.3%
Total Planning Area	104,854	98,260	\$73,540,652,648	276	\$627,729,946	0.9%

**Table 4.5.8 Community Lifelines located in the Six-Inch Sea Level Rise Inundation Area**

Location in Planning Area	Comm-unications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Trans- portation	Total
Bucoda	0	0	0	0	0	0	0	0
Lacey	0	0	0	0	0	0	0	0
Olympia	1	1	1	1	0	2	1	7
Rainier	0	0	0	0	0	0	0	0
Tenino	0	0	0	0	0	0	0	0
Tumwater	0	0	0	0	0	0	0	0
Yelm	0	0	0	0	0	0	0	0
Unincorporated Thurston County	0	0	1	0	0	0	6	7
<b>Total Planning Area</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>2</b>	<b>7</b>	<b>14</b>

## Impacts to Natural, Cultural, and Historic Resources

Sea level rise aggravated erosional forces, dispersion of pollutants and toxic substances, sediment deposition, and debris can create near-term or permanent adverse impacts to agricultural lands and on and offshore natural resources. There could be loss of wildlife habitat and changes to the quality and availability of fresh water due to inundation by salt water. Beaches, shellfish beds, estuaries, wetlands, and tide flats could be adversely impacted. Changes to these resources can be detrimental to areas that are valued by communities and tribes for their economic, ecological, food resource, and recreational benefits.

Tolmie State Park, Squaxin Park in Olympia, and Burfoot and Frye Cove parks in Thurston County are the region's most popular Puget Sound beach destinations. The highly valued shorelines of these parks are at risk to inundation from a six-inch or greater sea level rise. The loss of such park acreage would dramatically reduce public access to local marine shorelines.

## Impacts to Activities

Downtown Olympia is the region's most dynamic economic, social, cultural, and artistic hub. It is a major employment center for both the private and public sectors. Downtown shops and restaurants attract residents and visitors alike. Capitol Lake, Percival Landing, and the Port Plaza are year-round popular outdoor attractions and gathering places, especially

during festivals and events. Sea level rise threatens this vitality. However, the Olympia Sea Level Rise Response Plan includes strategies for protecting these assets.

## Risk Ratings

### Social Vulnerability Rating and National Risk Index

Social vulnerability is the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. As a consequence enhancing risk component of the National Risk Index, a Social Vulnerability score and rating represent the relative level of a community's social vulnerability compared to all other communities at the same level. A community's Social Vulnerability score measures its national rank or percentile. A higher Social Vulnerability score results in a higher Risk Index score. Map 4.5.2 shows assets and structures in Thurston County that are located in the sea level rise inundation areas by census tract social vulnerability ratings. Most areas affected by sea level rise have a rating that ranges from very low to relatively moderate.

The Federal Emergency Management Agency does not include a sea level rise hazard in its National Risk Index (NRI). However, the NRI for coastal flooding in Thurston County is 74.4 or relatively low. The rating represents a community's relative risk for coastal flooding when compared to the rest of the United States.

For comparison, Pierce County's NRI coastal flooding score is 73.6, also relatively low. The NRI reports an estimated coastal flooding hazard annual loss of \$1.2 million.

## Community Hazard Risk Ratings for Sea Level Rise Inundation Areas

The countywide sea level rise inundation risk ranking score is 18, a medium risk. Unincorporated Thurston County and the City of Olympia risk ranking scores are also 18. McLane Black Lake Fire District, Olympia School District, South Bay Fire District, and Thurston PUD each scored 9, a low risk. Sea level rise risk ranking scores are zero for all other communities. Tables 4.5.9 and 4.5.10 show community and special purpose sea level rise hazard risk ratings. The details of the sea level rise hazard risk assessment calculations are shown in Appendix C.

**Table 4.5.9 Community Sea Level Rise Hazard Risk Ratings**

Municipal Plan Participants	Sea Level Rise Hazard Risk Ranking Score	Risk Rating
Bucoda	0	Low
Lacey	0	Low
Olympia	18	Medium
Rainier	0	Low
Tenino	0	Low
Tumwater	0	Low
Yelm	0	Low
Unincorporated Thurston County	18	Medium
Total Planning Area	18	Medium

**Table 4.5.10 Special Purpose District Sea Level Rise Hazard Risk Ratings**

Special Purpose District Plan Participants	Sea Level Rise Hazard Risk Ranking Score	Risk Rating
East Olympia Fire District	0	Low
Intercity Transit	0	Low
Lacey Fire District	0	Low
McLane Black Lake Fire District	9	Low
Olympia School District	9	Low
SE Thurston Fire Authority	0	Low
South Bay Fire District	9	Low
The Evergreen State College	0	Low
Thurston PUD	9	Low
West Thurston Regional Fire Authority	0	Low

## Changes in Sea Level Rise Hazard Risks Since Last Plan Update

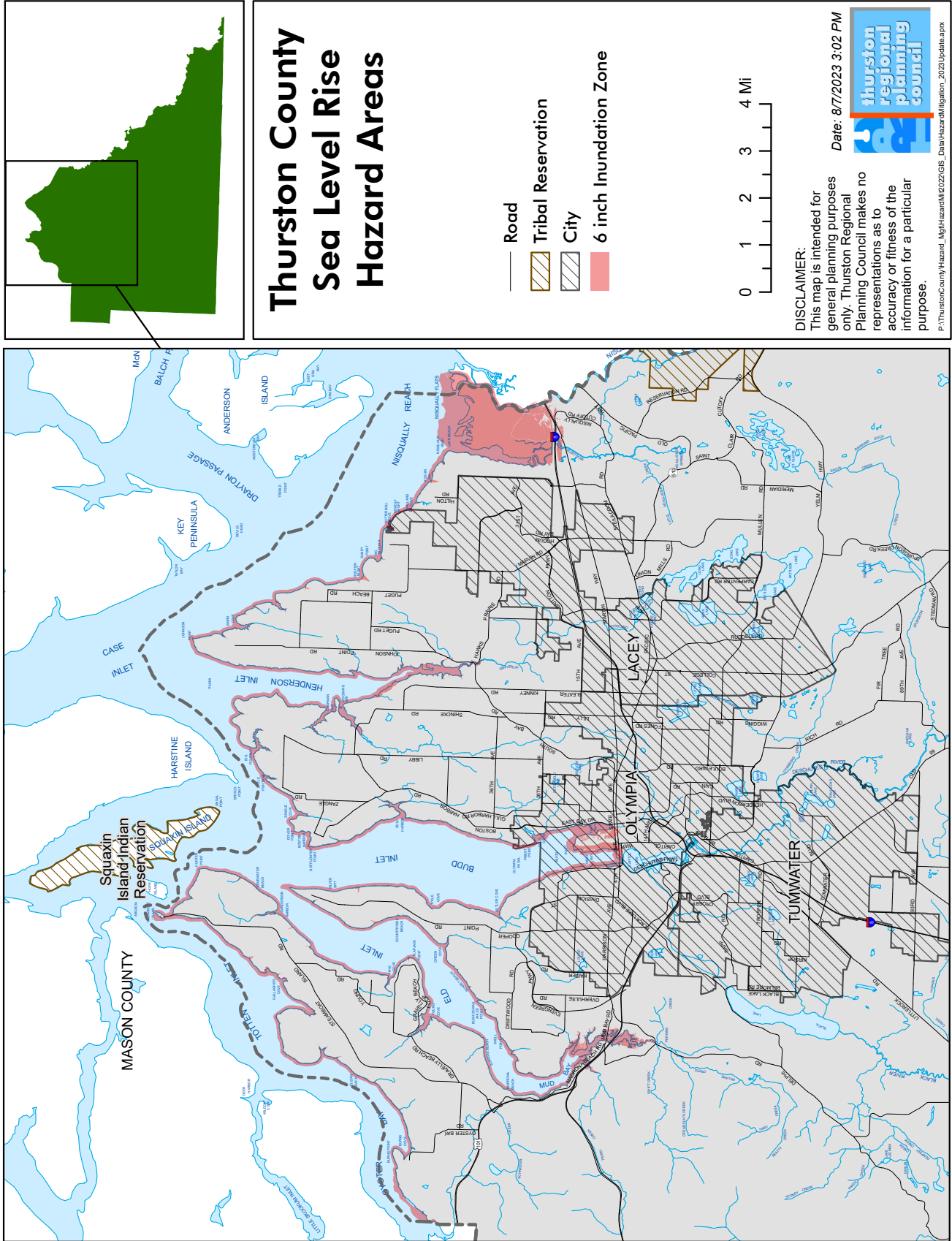
A countywide sea level rise scenario inundation map was unavailable to perform a vulnerability analysis and risk assessment during the development of the 2017 Hazard Mitigation Plan. The 2023 plan update process identified that approximately 0.9 percent of the population, 0.1 percent of assessed value of structures, and 14 community lifeline assets are potentially at risk for a six-inch sea level rise. This provides a baseline sea level rise hazard assessment for future evaluation of the region's vulnerabilities and risks.

## Connection to the Regional Mitigation Strategy

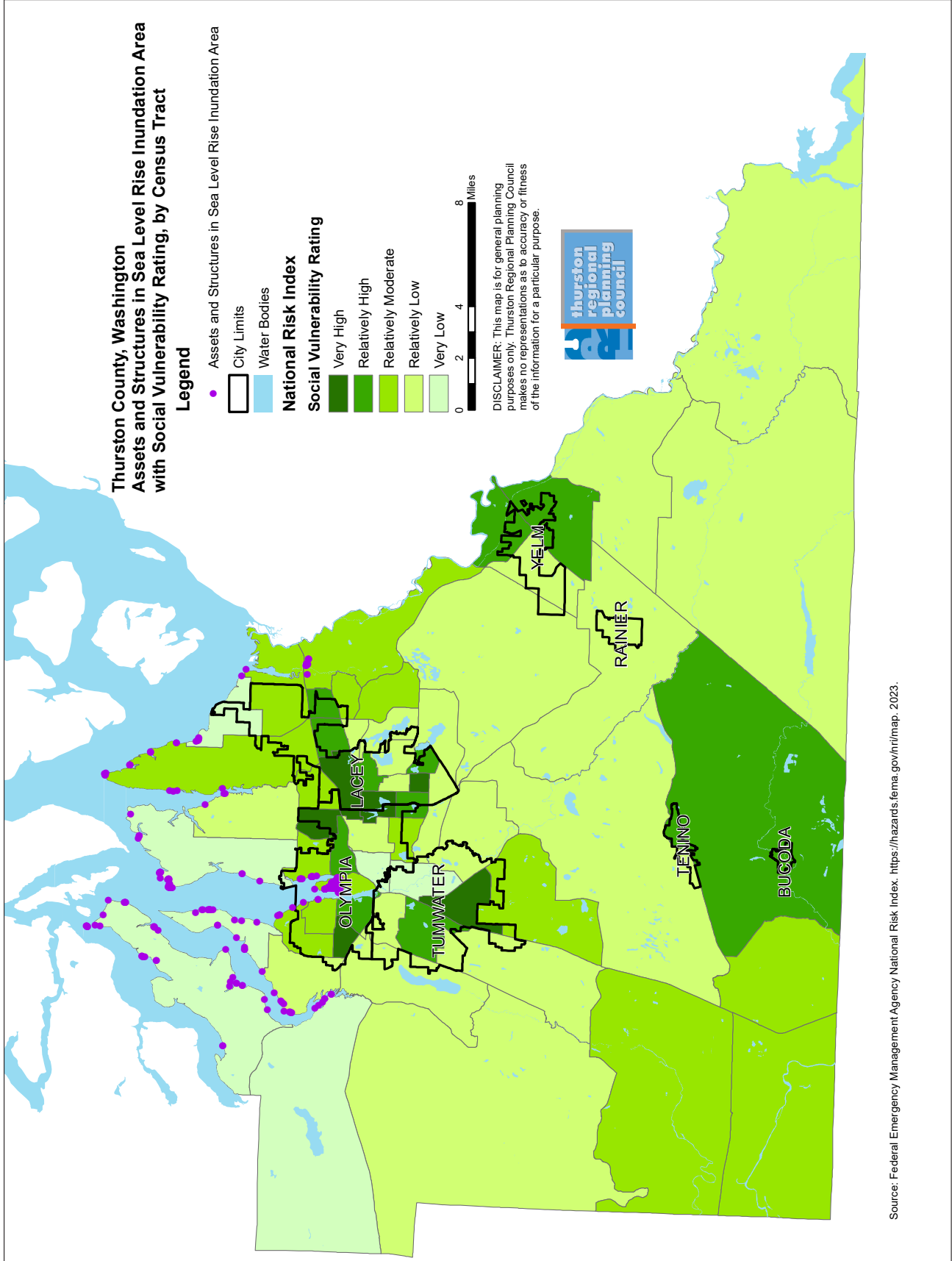
Downtown Olympia is one of the region's core economic and cultural hubs. Sea level rise impacts will extend well beyond downtown residents and businesses. The 2022 "Thurston County Communities Natural Hazards and Resiliency Survey" results show that City of Olympia, Tumwater, and Unincorporated Thurston County residents ranked climate change as one of the highest rated hazards of concern. Implementation of the Olympia Sea Level Rise Response Plan should be a regional priority.

Climate change induced hazards are novel and sea level rise education and preparedness for community residents is useful, both for its applicability to mitigation measures but also awareness to promote preparedness for residents who live on or near Thurston County's marine shoreline. Sea level rise hazard information will be included through the Regional Hazard Mitigation Public Outreach Strategy initiative.

Map 4.5.1 Six-Inch Sea Level Rise Inundation Areas of Thurston County



**Map 4.5.2 Exposed Assets and Structures in Six-Inch Sea Level Rise Inundation Area and Thurston County Social Vulnerability Index Rating by Census Tract**



## Endnotes

<sup>1</sup>Sweet, W.V. et. al. 2022. Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration. <https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf>

<sup>2</sup>Mauger, G.S. et. al. 2015. State of Knowledge: Climate Change in Puget Sound. Report prepared for the Puget Sound Partnership and the National Oceanic and Atmospheric Administration. Climate Impacts Group, University of Washington, Seattle.

<sup>3</sup>University of Washington Climate Impacts Group. 2023. Climate Mapping for a Resilient Washington: a Web Application for Climate Resilience Planning in Washington. <https://cig.uw.edu/resources/analysis-tools/climate-mapping-for-a-resilient-washington/>.

<sup>4</sup>City of Olympia, LOTT Clean Water Alliance, Port of Olympia. 2019. Olympia Sea Level Rise Response Plan.

<sup>5</sup>Personal Communication. August 11, 2023. Susan Clark, City of Olympia Water Resources and Drinking Water Utility, Engineering and Planning Supervisor.

