CHAPTER 4—
SEA LEVEL RISE
VULNERABILITY AND RISK
SEA LEVEL RISE VULNERABILITY AND RISK

The Project Partners conducted a vulnerability and risk assessment to evaluate flooding and sea level rise impacts to key assets, services, and operations within the Project Area. The Project Partners identified the sea level rise scenarios to be evaluated as part of the Plan, inventoried critical assets and operations, produced sea level rise inundation maps, and identified key vulnerabilities and risks.

WATER LEVEL AND SEA LEVEL RISE SCENARIOS

The vulnerability assessment evaluated the exposure of assets to coastal flooding as a result of king tides and the 100-year storm tide. King tide is a commonly used term to describe the highest astronomical tides that predictably occur a few times each year. The 100-year storm tide is a severe, rarely occurring flood event that is a combination of a high astronomical tide and storm surge. The 100-year storm tide has a 1-percent chance of occurring in any given year.

The vulnerability assessment evaluated sea level rise amounts of 0, 6, 12, 18, and 24 inches, combined with the king tide and storm tide water levels described above. The selected sea level rise scenarios correspond to the local Olympia sea level rise projections:

- 6 inches sea level rise: most-likely projection at 2030
- 12 inches sea level rise: most-likely projection at 2050; high-range projection at 2030
- 18 inches sea level rise: most-likely projection at 2060; high-range projection at 2040
- 24 inches sea level rise: most-likely projection at 2080; high-range projection at 2050

The vulnerability assessment did not evaluate sea level rise projections beyond 24 inches. The primary purpose of the assessment was to identify near-term impacts and tipping points to help prioritize the development and phasing of adaptation strategies. Beyond 24 inches of sea level rise, a large portion of Olympia would be exposed to extensive king tide and storm tide flooding. It is assumed that shoreline and stormwater improvements will have already been implemented before higher amounts of sea level rise occur. This does not mean that adaptation will stop at 24 inches of sea level rise. The physical adaptation strategies presented in Chapters 6 through 8 address sea level rise up to 68 inches.

KEY WATER LEVELS

The sea level rise vulnerability assessment evaluated exposure to coastal flooding as a result of king tides and the 100-year storm tide, as follows:

- **King Tide** (elevation 12.5 feet NAVD88 or 16.5 feet MLLW): a commonly used term to represent the highest astronomical tides that predictably occur a few times each year
- **100-year Storm Tide** (elevation 14.1 feet NAVD88 or 18.1 feet MLLW): a temporary increase in coastal water level due to a combination of high astronomical tide and storm surge due to low barometric pressure and local winds (not including wave effects at the shoreline, which may elevate flood levels higher)

Predicted amounts of sea level rise (e.g., 1 foot) are added “on top” of these baseline elevations to assess the vulnerability of downtown to sea level rise.
ASSET DATA INVENTORY

The Project Partners collected data on key assets and services located in the project area to better understand potential flooding vulnerabilities. They compiled geospatial data on asset locations, interviewed staff members during an asset data workshop with City, LOTT, Port, County, State, and Puget Sound Energy (PSE) representatives (PSE provides electricity to 1.1 million customers in western Washington, including all of Thurston County). The Project Partners also solicited input through a questionnaire completed by staff and during a Sea Level Rise Community Meeting through a workshop activity.

INDIVIDUAL ASSETS

The Project Partners compiled the information collected through the asset workshop and questionnaire into an asset database and grouped assets into categories for analysis in the vulnerability and risk assessment:

- **City Facilities**: buildings and facilities, parks, libraries, and museums
- **Fire and Police**: emergency response equipment, key access routes
- **Public Works**: pump stations, maintenance yards, sewer systems
- **Transportation and Parking**: City parking lots, roadways, and transit
- **Historic Structures**: such as those in the Olympia Downtown Historic District
- **LOTT Clean Water Alliance**: Budd Inlet Treatment Plant, pump stations, outfalls, force mains and interceptors
- **Port of Olympia**: buildings and facilities, terminals, marinas and boatworks, tenants
- **State/County/Federal Facilities**: buildings and facilities, parks
- **Private Utilities**: power substations, gas lines, and communications
- **Social Services**: community services
- **Community Assets**: private marinas, Farmer’s Market, and theaters
- **Employment**: downtown employment

GROUP ASSETS

Some of the categories contained assets that were too numerous to evaluate on an asset-by-asset basis. These asset types were treated as “group” assets and evaluated at a higher level. This evaluation included City assets and others that are part of the stormwater and sewer system. Examples of group assets include street trees, catch basins, fire hydrants, parking lots, contaminated sites, and street lights.

The full asset inventory is included as an attachment to the Vulnerability and Risk Assessment (Appendix D).

FLOOD PROTECTION AND CRITICAL FACILITIES

Even a very small chance of flooding of Olympia’s critical facilities may pose an unacceptable level of risk. Downtown Olympia contains a number of critical facilities that must be protected for the health and safety of our community.

The Federal Emergency Management Agency (FEMA) provides guidance on identifying critical facilities, which are those that provide services and functions essential to a community, especially during and after a disaster. Examples of critical facilities include: police and fire stations, vehicle and equipment storage, emergency response centers, medical facilities, schools and day care centers, power generating stations, and drinking water and wastewater infrastructure such as pumping stations and treatment plants.

FEMA recommends that, if possible, critical facilities should be located outside of high-risk flood areas. If a critical facility must be located within a flood area, it should be designed to higher protection standards and have flood evacuation plans in place. Protection of critical facilities could be achieved by designing these facilities to a higher standard, such as the 500-year flood level, or incorporating additional freeboard – for example, building to three feet above the base flood elevation (100-year flood level). This may also include elevating critical vehicular corridors that provide access to and from critical facilities so that fire and rescue equipment can travel safely during floods.

DOWNTOWN FLOODING AND SOCIAL EQUITY

The Plan acknowledges the potential impacts of sea level rise and flooding on vulnerable populations. Downtown residents could see their housing, services, and transportation networks disrupted by rising waters. In the next decade or two, we foresee unmanaged floods to be of short duration and without appreciable impacts to residents. However, in the longer term, unmitigated flooding could impact downtown residents, businesses, services, and transportation.
VULNERABILITY ASSESSMENT APPROACH

The vulnerability assessment followed a standardized process to evaluate exposure, sensitivity, and adaptive capacity of assets:

- **Exposure**: the nature and degree to which an asset, population, or system is exposed to sea level rise and flooding
- **Sensitivity**: the degree to which the physical condition and functionality of an asset, population, or system is affected by flood waters
- **Adaptive capacity**: the degree to which an asset, population, or system is susceptible to and able (or unable) to cope with adverse impacts of flooding

Assets are considered most vulnerable to sea level rise if they are exposed to flooding, are highly sensitive to (the damages from) floodwaters and are not easily adaptable.

**EXPOSURE**

The Project Partners created sea level rise inundation maps to evaluate asset exposure to king tide and 100-year storm tide events. The inundation maps were created by projecting each water level and sea level rise scenario overland and estimating the extent and depth of flooding. In addition, the inundation maps also delineate the shoreline and identify locations of shoreline overtopping for each mapped scenario. Exposure was evaluated by comparing the location of each asset to the flood extents for each water level and sea level rise scenario. Sea level rise exposure maps were developed for existing conditions and 6, 12, 18, and 24 inches of sea level rise (Figures 8–11). The maps also show inundation pathways for floodwaters to reach low-lying inland areas.

**SENSITIVITY**

Asset sensitivity was evaluated qualitatively based on considerations unique to different asset types. Each type has different sensitivities to flooding. Sensitivity to flooding was characterized for the following asset types: buildings and structures, transportation network, recreation and parks, and utilities. Example sensitivity considerations for two of the asset types, buildings and structures and utilities, are shown below:

- **Buildings and structures**
  - **Age and condition**: Older construction structures are more likely to be damaged by floodwaters
  - **Presence of electrical equipment**: Flooding of critical electrical equipment may lead to operation malfunction or failure of asset
  - **Life safety assets**: Certain facilities, such as fire/police stations, and emergency response centers, are more likely to have an appreciable impact on the community if damaged by floodwaters
  - **Elevation**: Some facilities are elevated above the adjacent ground elevation, making them less sensitive to damage by floodwaters

- **Utilities**
  - **Age and condition**: Older structures are more likely to be damaged by floodwaters
  - **Presence of electrical equipment**: Inundation of electrical equipment may lead to operation malfunction or failure of asset
  - **Presence of buildings and structures**: Buildings are likely to house mechanical and electrical equipment on lower floors that could be damaged if exposed to flooding
  - **Stormwater mains**: High tides and storm surge may reduce the capacity of the stormwater system to collect and convey runoff
  - **Sanitary sewer mains**: Flooding may increase rates of infiltration into sanitary sewer lines, thereby reducing the pipe’s capacity to collect and convey wastewater

The sensitivity considerations for other asset types and sensitivity analysis are summarized in an attachment to the Vulnerability and Risk Assessment (Appendix D).

**ADAPTIVE CAPACITY**

Adaptive capacity evaluates the asset’s ability to adjust to inundation or flooding in order to maintain its function or service. Adaptive capacity was assessed qualitatively based on a set of considerations that are applicable to each asset type, as follows:

- **Ability to elevate**: Existing asset can easily be raised to reduce vulnerability to flooding (for example, electrical panels may be exposed to floodwaters, but could be elevated without much effort or cost)
- **Ability to relocate**: Asset can easily be moved to higher elevation or outside of the floodplain to protect from flood damage (for example, City fleet vehicles are parked on a lot exposed to flooding, but could be
moved to another location during temporary flooding events)

- **Redundancy**: Presence of back-up generator, or an alternative building, or multiple access paths (alternative roadways and bus routes), or other means to provide asset substitution

- **Ability to adapt**: Assumes asset can adapt and be resilient to changes and recover from individual extreme events

The adaptive capacity analysis is summarized in an attachment to the Vulnerability and Risk Assessment (Appendix D).

### KEY VULNERABILITIES, RISKS, AND FOCUS AREAS

The sections that follow present an overview of city-wide sea level rise impacts followed by more detailed discussion of specific vulnerabilities within four focus areas evaluated as part of the Plan.

### SUMMARY OF CITY-WIDE SEA LEVEL RISE IMPACTS

A summary of sea level rise impacts to land, employment, residents, buildings, and roads is provided in Table 4 for sea level rise of up to four feet above the current 100-year flood level in Budd Inlet. As sea levels rise, high water events in Budd Inlet will inundate more area, impact people’s homes and places of work, and disrupt travel on Olympia’s streets.

### FOCUS AREAS

Key vulnerabilities are identified using the concept of “focus areas”. Each focus area has relatively common landscape traits, flood dynamics, and flooding vulnerabilities. Strategies for the different focus areas would work together to provide comprehensive flood protection for downtown. Four focus areas are identified for evaluation of vulnerabilities (Figure 7):

1. Capitol Lake / Lower Deschutes Watershed
2. Percival Landing and Isthmus
3. Budd Inlet Treatment Plant and Combined Sewer System
4. Port of Olympia Peninsula

The physical adaptation strategies presented in Chapter 6 follow this same framework. The key vulnerabilities identified within each focus area are summarized below.

### CAPITOL LAKE / LOWER DESCHUTES WATERSHED FOCUS AREA

This focus area presents the foremost flooding risk under both current and future conditions. The eastern shoreline of Capitol Lake has flooded repeatedly over the years. Currently, the area is highly managed by the City of Olympia and Washington State Department of Enterprise Services staff during high tides and/or high flows in the Deschutes River.

Table 4: Olympia Exposure to Sea Level Rise

<table>
<thead>
<tr>
<th>Elevation (feet)</th>
<th>Sea Level Rise</th>
<th>Land Inundated1</th>
<th>Employment2</th>
<th>Residential Population3</th>
<th>Buildings Impacted4</th>
<th>Roads Impacted</th>
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<tbody>
<tr>
<td>NAVD88</td>
<td>MLLW (feet)</td>
<td>(feet)</td>
<td>(acres)</td>
<td>(Number People)</td>
<td>(Number People)</td>
<td>(Number and [Value])</td>
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<td>7000</td>
<td>1988</td>
<td>337 [$370.3M]</td>
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</tbody>
</table>

Table 4 Notes:

1. Includes only acres above 13 feet NAVD88
4. A building was considered affected if it was in contact with flood water, values based on Thurston County Assessors parcel data (August 2016)
Shoreline elevations along Capitol Lake are approximately 13 to 14 feet NAVD88, compared to a 100-year flood level of approximately 15 feet. Under existing conditions, flood waters in Capitol Lake can overtop the Heritage Park shoreline and travel eastward and northward to inundate the following downtown areas:

- Heritage Park
- Railroad and tunnel
- Powerhouse Road
- Low-lying business district between 4th and 7th Avenues and Columbia and Simmons Streets

With low to moderate amounts of sea level rise (6 to 12 inches), Capitol Lake floodwaters could also inundate the Powerhouse, and a portion of the downtown Olympia historic district.

**PERCIVAL LANDING AND ISTMUS FOCUS AREA**

A walk along Percival Landing during a king tide highlights the vulnerability of this focus area. During king tide events, water nearly reaches the top of the wooden boardwalk and overtops low-lying areas of the shoreline. The low elevation of the shoreline and the Landing combined with the limited available area for construction of new flood protection barriers are characteristic of this focus area.

The average elevation of the Percival Landing and Isthmus shoreline is 14 to 15 feet NAVD88, but portions are as low as 12.5 feet (the approximate elevation of an annual king tide). The 100-year coastal flood level is approximately 14 feet in this area. Under existing conditions, a large coastal storm event could flood
the Percival Landing and Isthmus areas. With low to moderate amounts of sea level rise (6 to 12 inches), substantial flooding of the shoreline and inland areas could occur, potentially impacting the following assets:

- Olympia Center
- Water Street Lift Station (between Olympia Avenue and State Avenue)
- Percival Landing Park and Harbor House
- Key transportation corridors (4th Ave., Capitol Way)
- Waterfront restaurants and businesses

With moderate amounts of sea level rise (12 to 18 inches), marine floodwaters could travel eastward to impact larger areas of downtown and the Budd Inlet Treatment Plant, and northward to the marine terminal. Flooding along Percival Landing has implications to all three Project Partners.

**BUDD INLET TREATMENT PLANT AND COMBINED SEWER SYSTEM FOCUS AREA**

The LOTT Clean Water Alliance is a nonprofit governmental organization responsible for wastewater management services for the urban areas of Lacey, Olympia, and Tumwater in north Thurston County. LOTT currently serves a population of approximately 118,000 people. The Budd Inlet Treatment Plant (BITP) is LOTT’s main treatment facility, processing approximately 14 million gallons of wastewater on an average day. Effective 24/7 operation of the plant is essential for our local public and environmental health. The potential future interaction of sea level rise with the BITP is complex and extends well beyond the confines of the plant site.

Sea level rise could impact the BITP in a number of ways. The primary near-term concern for the BITP is overland flooding from Budd Inlet and Capitol Lake and the impact to the combined sewer system in downtown Olympia. The combined sewer system conveys sewage from homes and businesses as well as stormwater from downtown streets to the BITP. During flood events, floodwaters can overtop the shoreline and travel overland and through the streets to flood catch basins that collect stormwater and carry it into the combined sewer system (Figure 13). This additional volume of water mixes with wastewater and is conveyed to the BITP.

The surcharge of combined floodwater and wastewater could overwhelm the treatment plant and result in additional treatment costs or increased likelihood of bypasses, in which untreated or partially treated wastewater is discharged directly to Budd Inlet through LOTT’s marine outfalls. Additionally, if the treatment plant was overwhelmed by incoming flows, wastewater could back-up into the City’s sewer collection system overland from Budd Inlet and Capitol Lake and the impact to the combined sewer system in downtown Olympia. The combined sewer system conveys sewage from homes and businesses as well as stormwater from downtown streets to the BITP. During flood events, floodwaters can overtop the shoreline and travel overland and through the streets to flood catch basins that collect stormwater and carry it into the combined sewer system (Figure 13). This additional volume of water mixes with wastewater and is conveyed to the BITP.

**OLYMPIA’S COMBINED WASTEWATER AND STORMWATER TREATMENT SYSTEM**

In the mid-20th century, growing cities often combined wastewater with stormwater runoff flows from streets into one pipe system, the combined system. The pipes were then routed to wastewater treatment plants. This design occurred in large parts of downtown Olympia and in some of Olympia’s older residential neighborhoods. Separating stormwater and wastewater flows into two piping systems now would be technically difficult and expensive. Fortunately, the Budd Inlet Treatment Plant currently has the capacity to treat typical wet season stormwater flows.
and potentially flood streets, homes, and businesses. During such a flood event, the primary activity of the treatment plant would be to convey incoming flows (comprising seawater, stormwater runoff, and sewage) through the plant and discharge it to Budd Inlet to alleviate upstream flooding.

The Project Partners used the sea level rise inundation maps to identify the location of stormwater catch basins in downtown Olympia that could convey floodwaters from the street to the BITP. Figure 13 shows the location of inundated catch basins for king tide and 100-year storm tide events for 0, 6, 12, 18, and 24 inches of sea level rise. Under existing conditions, approximately 25 catch basins primarily along 4th Avenue could be exposed to floodwaters during a large coastal storm event; however, with only 6 inches of sea level rise, that number increases to 150 dispersed around the downtown area.

Street flooding and higher groundwater levels due to sea level rise may contribute to increased rates of infiltration into underground pipes, further increasing peak flows. These peak flows could overwhelm the plant’s hydraulic capacity. High concentrations of marine water (with high salinity content) in flood flows could also disrupt the biological treatment processes, which would require months to recover. Sea level rise will also increase water levels in Budd Inlet and require more frequent and longer duration pumping to discharge treated wastewater through LOTT’s marine outfalls.

With moderate amounts of sea level rise (18 to 24 inches), overland flooding from Percival Landing and East Bay may also expose and damage BITP structures and interrupt operations during large coastal storm events. On-site facilities that may be vulnerable to flooding with moderate sea level rise include:

- Main utilidor (an underground corridor containing piping and pumps)
- Maintenance building
- Solids handling building
- Anaerobic Digesters
- Puget Sound Energy Thurston substation

PORT OF OLYMPIA PENINSULA FOCUS AREA

The Port of Olympia oversees extensive land area and shoreline. This focus area encompasses the restricted-access marine terminal as well as popular public access to the shoreline and associated recreation. The Port serves all citizens of Thurston County through property tax levies.

The shipping berth, marine terminal, and Port Plaza shorelines are 15 to 16 feet NAVD88 elevation on average; however, there are some low spots south of Port Plaza and at North Point with elevations as low as 13 feet. The 100-year coastal flood level is approximately 14 feet in this area. Under existing conditions, these low spots could lead to minor flooding of Port property during a large coastal storm event. With low to moderate sea level rise (6 to 12 inches), floodwaters could travel southward from North Point and northward from Percival Landing and impact the following assets:

- Marine Terminal (cargo yard, rail, and Warehouse A)
- Cascade Pole site and the groundwater treatment facility
- Stormwater pumping station
- Port Plaza and Farmers Market

The East Bay shoreline is generally higher in elevation (approximately 16 feet NAVD88) and assets along East Bay would not be exposed to flooding until moderate sea level rise (18 to 24 inches). With moderate sea level rise, a coastal storm event could impact the following Port assets:

- Olympia Area Rowing Center
- Swantown Marina and Boatworks
- Shipping berths
- Key transportation corridors (Marine Drive)
Figure 8. Inundated Assets at No Sea Level Rise
Figure 9. Inundated Assets at 6 Inches of Sea Level Rise
Figure 10. Inundated Assets at 12 Inches of Sea Level Rise
Figure 11. Inundated Assets at 18 Inches of Sea Level Rise
Figure 12. Inundated Assets at 24 Inches of Sea Level Rise
Figure 13. Locations of Stormwater Catch Basins that Drain to the Budd Inlet Treatment Plant

Note: KT = king tide and ST = 100-year storm tide in figure legend.