FINAL

TACOMA CRITICAL AREAS AND CLIMATE CHANGE: BEST AVAILABLE SCIENCE AND PRACTICES

Prepared for
City of Tacoma

June 2023

ESA

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CHAPTER 1
Climate Change and Critical Areas in Tacoma

Critical areas defined in Chapter 13.01 of the Tacoma Municipal Code (City of Tacoma 2023) include wetlands, streams, fish and wildlife habitat conservation areas, frequently flooded areas, geologically hazardous areas, and aquifer recharge areas. These areas provide critical ecosystem functions and services, including flood and erosion control, groundwater recharge, fish and wildlife habitat, water and air purification, cultural resources, and recreation. These natural habitats may help to buffer the impacts of climate change in the city, including warmer air and stream temperatures, more extreme winter storms and flood events, sediment loading of waterways, rising sea levels, and lower summer streamflows. This section summarizes key concerns related to climate change and critical areas in Tacoma.

1.1 Wetlands

- Wetlands supplied by surface water may experience more frequent drying as summers become warmer and snowpack is depleted more rapidly in spring (WSDOE 2023; CIG n.d.). This may cause shifts in species assemblages and increase the risk of habitat conversion and/or habitat loss and degradation for aquatic, avian, and terrestrial species that rely on wetlands for habitat (WDFW 2015). Wetlands supplied by groundwater are expected to be less vulnerable to climate change (City of Tacoma ESD 2016), though increased groundwater demand for agricultural, commercial, or residential uses may stress naturally available water supplies.

- Increases in winter precipitation may have positive effects on wetlands by creating additional side channel habitat; however, heavy rainfall may also diminish the ability of soils and vegetation to effectively store water and attenuate floods and erosion (WDFW 2015).

- Estuarine and freshwater wetlands are found along Tacoma's shoreline, many of which are within the boundaries of the port (Port of Tacoma n.d.). As sea levels rise, these low-lying areas are highly susceptible to inundation. Coastal freshwater wetlands are likely to experience shifts in plant dominance towards more salt-tolerant species. Estuarine wetlands will likely be unable to migrate inland as sea levels rise as they are backed by developed areas.

- Wetlands are carbon sinks and changes to their viability due to drying induced by higher temperatures and drought may result in that carbon being released to the atmosphere (Salimi et al. 2021). As sea level rise, wetlands can also drown, releasing carbon back into the system (Thorne et al. 2018).

1.2 Streams

- Warming stream temperatures will affect species that require cool waters such as salmonids by inhibiting their migration and breeding patterns (Mantua et al. 2010).

Within city limits, streams and rivers that provide habitat for salmon include the Puyallup River, Leach Creek, Swan Creek, Chambers Creek, and Joe's Creek (Pierce County n.d.).

- Streamflows are anticipated to decrease during summer months as the snowpack reserve melts. For streams that traverse developed areas, culverts, or other infrastructure, decreased flows may exacerbate the effects of these barriers on fish species movement. Heavy rainfall will exacerbate polluted runoff from impervious surfaces, particularly if municipal stormwater systems and/or green infrastructure cannot adequately handle increased flow rates (USEPA n.d.). Pre-spawn mortality of coho salmon has been attributed to polluted urban stormwater runoff that decreases dissolved oxygen levels (Mauger et al. 2015).

- Wildfires upstream could contribute to increased sedimentation of waterways due to post-fire erosion and flooding (Raoelison et al. 2023).

- As drought and extreme heat events co-occur, terrestrial plant species in riparian habitats will face greater stress and mortality, and may be unable to provide shade to streams and rivers (Raymond et al. 2014; USFS n.d.).

- Increased drought conditions will also likely reduce water availability in riparian habitats, which will impact seedling germination rates and tree survival (WDFW 2015).

1.3 Fish and Wildlife Habitat Conservation Areas

- Shifting seasonal patterns such as an earlier incidence of spring conditions and a longer, warmer, and drier summer period will likely create timing mismatches between the availability of food sources and life cycle events such as reproduction and migration (Snover et al. 2013).

- The National Audubon Society identified 122 bird species in Pierce County inclusive of migratory species that are susceptible to climate change impacts by late-century (Audubon 2019). Contributing factors include shifting seasonal conditions causing disruptions to migration patterns and prey availability, and loss of habitat due to conversion, mortality, and inundation from sea level rise. Rising sea levels may result in the loss of nearshore habitat in areas with hard shoreline armoring such as seawalls or bulkheads as is the case for the majority of shoreline within and immediately surrounding Tacoma (City of Tacoma ESD 2016; Puget Sound Nearshore Ecosystem Restoration Project [PSNERP] n.d.).

- Increased peak streamflows may scour streambeds and salmon redds, affecting egg survival (Tohver et al. 2014).

- Some plant species may experience increased heat and drought stress and subsequent infestation by pests and pathogens (Raymond et al. 2014).

1.4 Frequently Flooded Areas

- Flood risk is expected to increase in Tacoma. Some flood protection infrastructure is aging and may not be adequate to accommodate increased streamflows. Smaller urban

creeks are also expected to experience more frequent flooding (City of Tacoma ESD 2016).

- Components of the stormwater system that are already experiencing capacity challenges will be more likely to flood during larger, more intense precipitation events (City of Tacoma ESD 2016).

- Sea level rise will increase the extent, depth, and duration of flooding, making it more difficult for rivers to drain to Puget Sound (Mauger et al. 2015). Sea level rise will permanently inundate some low-lying areas with the extent and depth of inundation depending on shoreline characteristics such as elevation, drainage pathways, and the presence of armoring or other flood protection structures (Mauger et al. 2015). These impacts will be exacerbated by storm surge and king tides.

1.5 Geologically Hazardous Areas

- Shifting precipitation patterns are likely to increase the occurrence of landslides and accelerate erosion (Mauger and Vogel 2020), particularly in areas that are susceptible to geological hazards. Areas of moderate and high potential geological hazard are concentrated along Tacoma's shorelines, Puget Creek, Buckley Gulch, Garfield Gulch, Swan Creek, in Chambers Creek Canyon, and East of the Interstate-5/WA-7 interchange (City of Tacoma GIS n.d.; City of Tacoma ESD 2016). Ruston Way and Marine View Drive have also been identified as being at increased landslide risk (City of Tacoma ESD 2016).

- Drier conditions and soils are likely to increase landslide risk by widening gaps in rocks and soils (Mauger et al. 2015).

- Increased streamflow may cause more aggressive channelization of waterways and increase bank instability (Mauger et al. 2015).

- Declines in vegetative cover along streambanks may contribute to higher erosion risk (Raymond et al. 2014).

- Coastal bluffs and areas that are subject to tidal influence will likely experience greater rates of erosion with sea level rise (Huppert et al. 2009; Mauger et al. 2015).

1.6 Aquifer Recharge Areas

- Coastal aquifers may become more susceptible to saltwater intrusion due to sea level rise (Huppert et al. 2009).

- Because Tacoma relies on a series of groundwater wells to supplement surface water sources during periods of peak demand reduced summer flows and droughts will likely prompt increased groundwater withdrawals (City of Tacoma ESD 2016).

- More intense precipitation events anticipated with climate change may create operational difficulties for drinking water systems including damage, loss of power, and the intrusion of pollutants into wells and distribution systems (Siemann and Whitely Binder 2017).

- Reduced summer streamflows are expected to diminish the function of floodplain areas, including the recharge of groundwater aquifers (Siemann and Whitely Binder 2017).

- Snowpack and snowmelt play an important role in groundwater recharge in Pierce County. Reductions in snowpack and more rapid melting of snow may decrease groundwater recharge and cause increased variability in groundwater supplies in the county (Pitz 2016).

CHAPTER 2
Critical Areas Ordinances

There are numerous opportunities for the City of Tacoma to integrate up-to-date science on both effective critical areas management strategies and how climate change will affect these areas and their management. This section presents findings from a rapid literature review (and interviews where possible) to document efforts undertaken by other Washington municipalities to integrate emerging state guidance on riparian and wetland management, water supply and storage considerations (particularly with respect to aquifer recharge areas), climate-informed updates to municipalities' critical areas policies, and nearshore, stream, and riparian buffer considerations in light of climate change.

2.1 Benchmarking

In 2020, the Washington Department of Fish and Wildlife (WDFW) released series of new guidance documents (Quinn et al. 2020; Rentz et al. 2020), detailing the Best Available Science (BAS) and management recommendations for riparian ecosystems in the State of Washington. In 2022, the Washington State Department of Ecology (WSDOE) released *Wetland Guidance for Critical Area Ordinance (CAO) Updates: Western and Eastern Washington*. Each of these documents are intended to help guide jurisdictions in making scientifically sound decisions as they update their CAOs.

To identify jurisdictions that have implemented some or all the guidance from the documents above, a benchmarking review was completed. For the benchmarking process, CAOs were reviewed for the following 39 jurisdictions:

Anacortes	Everett	Olympia
Arlington	Federal Way	Pierce County
Bainbridge Island	Friday Harbor	Port Orchard
Bellevue	Gig Harbor	Redmond
Bellingham	Island County	Renton
Benton County	Issaquah	San Juan County
Bremerton	Jefferson County	Seattle
Burien	King County	Skagit County
Cheney	Kittitas County	Snohomish County
Clallam County	Langley	Spokane (City)
Clark County	Lynnwood	Spokane County
Cle Elum	Mason County	Thurston County
Edmonds	Mount Vernon	Whatcom County

Notably, the 2022 WSDOE guidance is in part a synthesis that builds from a wetland identification methodology first published in 2014 and a 2021 report on mitigation strategies including compensatory mitigation, among other previously released documents. This means that many of the jurisdictions reviewed that had updated the wetlands section of their CAOs after 2014 were partially in agreement with the new guidance; these jurisdictions were omitted from the list of adopters discussed below.

For jurisdictions where no public-facing updates were found, an email was sent to local staff members inquiring about ongoing update processes that may not yet be publicly available. Of jurisdictions that replied, only **Issaquah** indicated that an update to the CAO is in progress while **Snohomish County** reported that it had begun a BAS process. All other respondents reported that they had not yet begun the update process, with most indicating that the CAO update would begin after completing Comprehensive Plan updates.

2.2 Adopters of New Wetland and Riparian Guidance

Through the benchmarking process, only **four** jurisdictions were identified with public-facing updates to CAOs that adopt any of the WDFW riparian or WSDOE wetlands guidance. **Anacortes** updated its stream buffer standards to accommodate the new WDFW guidance after appearing before a Growth Management Hearing Board. **Clark County** has fully adopted the WSDOE guidance and substantial parts of the WDFW guidance. **Benton County** adopted stream buffers that appear to be in concurrence with the 2020 WDFW guidance, though in a way that departs from Anacortes and Clark County. **Issaquah** updated its CAO in conjunction with a broader update to development codes; the city anticipates making further revisions through the coming years to include elements of the WSDOE guidance.

A fifth jurisdiction, **Cle Elum**, passed an update that included the 2020 WDFW guidance through its planning commission before it was abandoned by the City Council in early 2021.

2.2.1.1 Anacortes

An assignment of error was brought by an advocacy organization that held that the City of Anacortes failed to uphold both the GMA and its Comprehensive Plan regarding critical area buffers (specifically stream buffers). The Growth Management Hearing Board found that the city departed from BAS as established in Rentz et al. (2020) by permitting buffers of 50-feet for all streams. As a result, Anacortes was required to update its riparian buffer ordinances to reflect a BAS approach, electing to utilize 200-year Site Potential Tree Height as an indicator of appropriate buffer width (and the approach suggested in Rentz et al. 2020). Ordinance 4025 amended the code as such and can be viewed here.

2.2.1.2 Clark County

Rick Mraz, Wetlands Policy Lead with WSDOE, conferred in a phone interview that Clark County was the first jurisdiction he had seen to update its CAO and adopt the WSDOE guidance "whole cloth." Upon inspection of the adopted ordinance (here), it also appears that the WDFW riparian guidance has been adopted as well, utilizing the Riparian Management Zone (RMZ) model.

2.2.1.3 Benton County

Located on the Columbia Plateau, the geography and landscape of Benton County differs substantially from Tacoma and Western Washington. The adopted updates to the riparian buffers in the County's CAO appear to follow the WDFW guidance and represent a different approach to riparian area buffers. The link shows both a redline update and the comment/response matrix provided by the County. Of note are the comments of Elizabeth Torrey on page 13, requesting no changes to the proposed language on behalf of WDFW, seemingly indicating support for the chosen approach.

2.2.1.4 Issaquah

In June 2023, the Issaquah City Council adopted an updated CAO as a component of a larger development code update. This project has been ongoing since 2018, with work on the CAO beginning in 2021 and finishing in June 2023. Given the timeline, the 2022 WSDOE guidance was not incorporated, though further amendments are likely given upcoming land use code and comprehensive plan updates. As Issaquah is a heavily developed jurisdiction and the 2022 WSDOE guidance builds from the 2014 wetland identification tables previously released by WSDOE, the city anticipates few substantial changes.

Issaquah initially perceived the guidance from WDFW as being most applicable at the county scale and for larger landowners. Follow-up conversations with WDFW confirmed that the 200-year Site Potential Tree Height standard for RMZs is in fact intended to be implemented in developed areas as well, which prompted planners in Issaquah to explore what such a regulation would look like if implemented. Soil studies on shorelines of the state within Issaquah determined that the appropriate buffer under such a standard would be 175-200 feet, which in many cases in the old downtown area have already been fully built out. As implementing this standard would have created "hundreds of, if not a thousand" non-conforming sites, Issaquah contracted with The Watershed Company to prepare a BAS report to find a defensible alternative. Issaquah elected to implement a 150-foot buffer for primary shorelines, representing a 50-foot increase over the previous regulation.

Having completed a public engagement process for the CAO update, Issaquah reported minimal community pushback on its chosen ordinance, citing an engaged group of residents and advocacy organizations who regularly push the City to "do more" with regards to environmental regulation.

2.2.1.5 Cle Elum

Cle Elum drafted updates to its CAO before the WDFW guidance was released. Following the guidance release, Cle Elum received a request from Elizabeth Torrey on behalf of WDFW to incorporate the riparian buffers guidance. Responding to the request, the recommended amendments were updated and presented to the Planning Commission. Elizabeth Torrey, also a Cle Elum planning commissioner, recused herself on account of having submitted the request on behalf of WDFW.

Following further discussion at a second Planning Commission meeting, amendments that incorporated Site Potential Tree Height as the determinant for buffer widths along a local creek were passed. The amended ordinances appeared before Cle Elum's City Council for a first reading. At the following Council meeting (5/24/21), several councilmembers expressed concern over the ordinances, citing a desire for legal analysis by the City Attorney, requesting "accurate" maps, stating that previously properties abutting the creek had not been regulated because there was no buffer, and voicing concerns

over whether the ordinance would "affect the citizens." At the next meeting (6/14/21), the Mayor reported that the City would be conducting an internal review of the BAS and a report would be sent back to the Planning Commission before returning to City Council. At present, the city's CAO remains unchanged from its 2010 state

2.3 Gap Analysis and Emerging Updates

In addition to email inquiries, a review of any gap analyses and BAS reports was completed for the above jurisdictions to check for adoption of either the WDFW or WSDOE guidance. From this pool, two gap analysis reports were found: Langley and Pierce County. Both reports reference the WDFW guidance on riparian areas; neither reference the WSDOE wetlands guidance.

2.4 Aquifer Recharge Areas

2.4.1 Tacoma and Pierce County Comparison

Aquifer recharge areas' definitions and protection standards according to Pierce County and City of Tacoma (Table 1):

TABLE 1. COMPARISON OF AQUIFER RECHARGE DEFINITIONS AND PROTECTION STANDARDS BETWEEN THE CITY OF TACOMA AND PIERCE COUNTY

	Pierce County	**City of Tacoma**
Definition	Land areas where the prevailing geologic conditions allow infiltration rates which create a high potential for contamination of groundwater resources or contribute to the replenishment of groundwater. (19D.170.030)	Areas that, due to the presence of certain soils, geology, and surface water act to recharge groundwater by percolation. (13.01.110.A)
Classification	1. The boundaries of the two highest DRASTIC zones that are rated 180 and above on the DRASTIC index range, as identified in Map of Groundwater Pollution Potential, Pierce County, Washington, National Water Well Association, U.S. Environmental Protection Agency; and 2. The Clover/Chambers Creek Aquifer Basin boundary as identified in the Clover/Chambers Creek Basin Groundwater Management Program. (18E.50.030)	The following criteria should be considered in designating areas with critical recharging effects: **A.** Availability of adequate information on the location and extent of the aquifer; **B.** Vulnerability of the aquifer to contamination that would create a significant public health hazard. When determining vulnerability, depth of groundwater, macro and micro permeability of soils, soil types, presence of a potential source of contamination and other relevant factors should be considered; and **C.** The extent to which the aquifer is an essential source of drinking water. (13.11.810)
General Requirements for Review Procedures	1. The Pierce County Critical Areas Atlas-Aquifer Recharge and Wellhead Protection Area Map provides an indication of where aquifer recharge and wellhead protection areas are located within the County. 2. The Department will complete a review of the Aquifer Recharge Area Map for any development proposal to determine whether the proposed project area for a regulated activity falls within an aquifer recharge or wellhead protection area. 3. When the Department's maps or sources indicate that the proposed project area for a regulated activity is located within an aquifer recharge or wellhead protection area, the	N/A

	Pierce County	City of Tacoma
	Department shall require aquifer recharge and wellhead protection area review as set forth in this Chapter. 4. Any regulated activity located within an aquifer recharge or wellhead protection area shall comply with the standards set forth in PCC 18E.50.040. 5. Any hazardous uses, as defined in PCC 18E.50.040, shall require the submittal of a hydrogeologic assessment, as set forth in PCC 18E.50.030 B. below. 6. The Department may waive some of the critical area protective measure provisions contained in PCC 18E.10.080. (18E.50.040)	
Protection Standards	*General.* All regulated activities that are not exempt, prohibited, or otherwise excluded in the following standards under the provisions of this Chapter shall ensure sufficient groundwater recharge. In order to achieve sufficient groundwater recharge the applicant shall either comply with the impervious surface limitations set forth in Table 18E.50.040-Aor demonstrate that the volume of water infiltrated at the proposed project area will be the same or greater amount for post-development as the pre-development volume.	Standards for development in aquifer recharge areas shall be in accordance with the provisions in Chapter 13.09, South Tacoma Groundwater Protection District, of the TMC and other local, state, and federal regulations.

SOURCE: Pierce County CAO, City of Tacoma CAO

2.4.2 Water Supply Considerations

2.4.2.1 Pierce County

Current Pierce County regulations in aquifer recharge areas focus mostly on identification and classification, reducing contamination risks by limiting high-risk activities. To further guide and inform their CAO update, the County is implementing the current 2021 WSDOE Critical Aquifer Recharge Area (CARA) Guidance (WSDOE 2021a), which recommends the following steps to characterize and protect aquifer recharge areas:

- Identify where groundwater resources are located.
- Analyze the susceptibility of the natural setting where groundwater occurs.
- Inventory existing potential sources of groundwater contamination.
- Classify the relative vulnerability of groundwater to contamination events.
- Designate areas that are most at risk to contamination events.
- Protect by minimizing activities and conditions that pose contamination risks.
- Ensure that contamination prevention plans and best management practices implemented and followed, including application of BMPs in the Pierce County Stormwater Management and 10 Site Development Manual for new developments in aquifer recharge areas. Review BMPs for infiltration designs with water quality treatment in the Chambers/Clover Creek watershed because of high infiltration rates and high-water table conditions. Stormwater control usually affects the vadose zone

and seasonal water tables with low risk to deeper water supply aquifers. Some exceptions are those glacial outwash plains with extensive deposits of coarse gravels near the surface.

- Manage groundwater withdrawals and recharge impacts to:
  - Maintain availability for drinking water sources.
  - Maintain stream base flow from groundwater to support in-stream flows, especially for salmon-bearing streams

2.4.3 Impervious Surface Standards

Examples of impervious surface standards from other municipalities that the City of Tacoma could review, modify, and adopt were identified for the City of Sammamish and King and Pierce counties.

2.4.3.1 City of Sammamish

The Sammamish Unified Development Code (21.03.020) implements best management practices for critical areas to implement the goals of the GMA, State Environmental Policy Act (SEPA), and the City of Sammamish Comprehensive Plan:

- New single-family home construction or modifications or additions to existing single-family homes on existing legal lots that will result in a total site impervious surface of more than 2,000 square feet shall provide a drainage design, using the following sequential measures, which appear in order of preference: Infiltration of all site runoff shall be required to the maximum extent technically feasible in existing soil conditions, consistent with the infiltration system design requirements of the King County Surface Water Design Manual (KC SWDM).
- Groundwater Quantity Protection Standards. For developments in all CARA classes, the applicant shall provide surface water infiltration as follows:
  - a. Seventy-five percent of on-site stormwater volume generated from the proposed development shall be infiltrated; provided, that a lesser standard may apply or on-site infiltration may be waived when:
    - i. The applicant demonstrates that infiltration is not a reasonable alternative due to site-specific soil and/or geologic conditions;
    - ii. It is determined that increased saturation of soils would result in an increased risk to existing facilities and/or adjacent properties;
    - iii. Infiltration would result in significant unavoidable impacts to other critical areas or result in an excessive loss of native vegetation; or
    - iv. The applicant proposes an addition of no more than 700 square feet of total new impervious surface compared cumulatively to 2005 levels.

2.4.3.2 King County

King County's SWDM requires flow control BMPs to reduce runoff volumes and increase groundwater recharge by mitigating hydrologic impacts from new and existing impervious surfaces. Mitigating these impacts through flow control can help prevent the loss of vegetation diversity and habitat quality; disruption of spawning, egg hatching, and migration; and algal scour and washout of organic matter. Flow control BMPs the County aims to implement include, but are not limited to, the conservation and use of native vegetated surfaces, bioretention, permeable pavements, and reduction of development footprint.

King County Code (K.C.C. 9.04.050) requires flow control BMPs abide by the following standards:

- Proposed projects that would result in two thousand square feet or more of new plus replaced impervious surface or seven thousand square feet or more of land disturbing activity shall provide flow control BMPs that use processes such as infiltration, dispersion, storage, evaporation, transpiration, forest retention and reduced impervious surface footprint to mimic pre-developed hydrology and minimize stormwater runoff generated by new impervious surface, new pervious surface, replaced impervious surface and any existing impervious surface added on or after January 8, 2001, as specified in the [SWDM]. Flow control BMPs shall be applied to manage stormwater runoff from the aforementioned surfaces to the maximum extent feasible using lists of flow control BMPs specific to the project location, size and impervious coverage; or as required to demonstrate that developed discharge durations from the surfaces match pre-developed durations for those surfaces for the range of predeveloped discharge rates from eight percent of the two-year peak flow to fifty percent of the two-year peak flow as specified in the [SWDM].

2.4.3.3 Pierce County

Pierce County factors in impervious surface limitations within CARAs to achieve sufficient groundwater recharge (Table 2):

TABLE 2. IMPERVIOUS SURFACE LIMITATIONS - PIERCE COUNTY.

Comprehensive Plan Land Use Designation	Maximum Impervious Surface Coverage (1)
Urban Land Use Designations	
Employment Center	60%
Major Urban Center	75%
Activity Center	50%
Community Center	50%
Neighborhood Center	50%
Mixed Use District	75%
High Density Residential District	50%
High Density Single Family	50%
Moderate Density Single Family	35%
Public Institution	60%
Urban Military Land	Not Applicable
Master Planned Community	20%
Employment Based Planned Community	20%
Rural Land Use Designations	
Essential Public Facility Rural Airport North	PUD
Essential Public Facility Rural Airport South	PUD
Rural Activity Center	60%

Rural Neighborhood Center	50%
Gateway Community	50%
Rural Separator	10%
Rural Sensitive Resource	10%
Rural Farm	10%
Rural 10	10%
Rural 20	10%
Rural 40	10%
Reserve 5	10%
Master Planned Resort	10%
Rural Military Land	Not Applicable
Natural Resource Land Designations	
Designated Forest Land	Not Applicable
Agricultural Resource Land	Not Applicable

NOTES: (1)The maximum impervious surface coverage is calculated for the total amount of impervious surface per each individual site. The percentage for maximum total impervious surface per lot or site may be exceeded if the applicant can demonstrate that the effective impervious surface on the site is less than or equal to what is allowed for the total impervious surface.

SOURCE: Pierce County Critical Aquifer Recharge Areas

2.5 Climate Change-Informed Updates

2.5.1 BAS Reviews

As a component of the benchmarking process, BAS Reports and CAOs for the 39 jurisdictions listed in Section 2.1 were reviewed for the integration of climate change. **Bellingham**, **Cle Elum**, **Jefferson County**, **Kittitas County**, **Langley**, and **Pierce County** were the only jurisdictions to have climate change references within their BAS reports. Of these six, the majority referred to climate change as something to monitor, further study, or otherwise keep in mind, but did not include suggestions on management or regulatory activities to address climate change impacts.

Pierce County and **Langley** each included exploration of potential management actions that could support the mitigation of climate change impacts across each required section of the CAOs. These strategies (The Watershed Company 2022, 2023) are listed below. Some of these recommendations appear in the draft CAO update available on the City of Langley website (link). Many of these strategies align with those already implemented to protect critical areas and serve the purpose of reducing stress on critical areas so they are more capable of withstanding climate change (e.g., maintaining water storage capacity, maintaining vegetation to buffer runoff, etc.). Starred (*) strategies in Sections 2.5.1.1-2.5.1.5 are more targeted towards being responsive to climate change.

2.5.1.1 Critical Aquifer Recharge Areas Climate Strategies

- Review regulatory requirements for reclaimed water use and temporary dewatering during construction to ensure adequate protections are in place.

- Promote and incentivize low impact development, specifically infiltration of clean runoff to support aquifer recharge.

- Balance growth and development with preservation and restoration of open spaces and native vegetation tracts.

- Manage stormwater to maintain groundwater recharge in CARAs. Utilize 20-year planning horizon to manage supply and demand given climate trends and projections.*

- Adaptive management of stormwater has the potential to better mimic natural systems and mitigate for some of the functions lost elsewhere in the landscape due to changes in surface and groundwater inputs.* For example, the use of roadside bioswales may be expanded. Stormwater treatment capacity may be increased as needed to protect water quality and manage water quantity.

- Planning for increased flooding can reduce the likelihood of contaminated runoff events.*

- Preserve open space and concentrate urban development away from CARAs.

- Continue to protect CARAs by maintaining updated CARA maps and classifications.

- Continue to modify public outreach efforts to educate residents about best practices in CARAs and promote water conservation and water use efficiency programs.*

2.5.1.2 Fish and Wildlife Habitat Conservation Areas Climate Strategies

- Promote retention of significant trees and maintain tree replacement requirements.

- Encourage and incentivize enhancement and restoration of native forest patches throughout the jurisdiction, particularly where connectivity to one or more FWHCAs is demonstrated. Both voluntary and required restoration planting should be paired with monitoring and maintenance that allows for dry season irrigation and adaptive management.

- A broader native plant species palette in regulated FWHCAs could be allowed to increase resilience of plant communities considering climate stressors as new scientific recommendations on native plant tolerances are published.*

- Manage stormwater infrastructure to avoid and minimize discharges of untreated runoff to streams.

- Encourage the use of local nursery plant stock grown under current conditions to increase resilience of plant communities considering climate stressors.*

- Update and maintain regulations for habitats and species of local importance. This may include adding mapping resources to help identify the locations of potential habitats and species requiring protection and management.

- Prioritize protection of streams and riparian corridors to reduce the stresses of climate change on native fish species and anadromous fish, such as Chinook salmon.*

2.5.1.3 Frequently Flooded Areas Climate Strategies

- Establish a comprehensive flood hazard management plan (CFHMP) to support stormwater management, salmonid habitat, and streamflow planning.

- Encourage and incentivize floodplain restoration actions to restore floodplain connectivity to streams and wetlands.

- Utilize the FEMA Climate Resiliency approach to support flood hazard management planning and follow grant funding opportunities.

2.5.1.4 Geologically Hazardous Areas Climate Strategies

- Review and address landslide and erosion hazards to roads and infrastructure.

- Encourage or require climate-informed design for development and infrastructure in or near geologic hazard areas.*

- Require appropriate surface and ground water management practices for development near coastal bluffs.

- Encourage retreat and increased setbacks for bluff top development.*

- Encourage utilization of soft shore protection strategies.

- Identify and prioritize geologic hazards within the jurisdiction, then update mapping as needed using current practices like LiDAR and GIS database tools.

- Keep in communication with the Governor's office to ensure the jurisdiction is included in statewide collaborative efforts to manage geologic hazard areas.

2.5.1.5 Wetlands Climate Strategies

- Continue to encourage and incentivize direct wetland impact avoidance to maintain existing carbon storage.*

- Continue to regulate wetland buffers to encourage and require width retention/limitations and enhancement with native vegetation. Both voluntary and required restoration planting should be paired with monitoring and maintenance that allows for dry season irrigation and adaptive management.

- Manage stormwater infrastructure to avoid and minimize discharges of untreated runoff to wetlands.

- A broader native plant species palette in regulated wetlands and wetland buffers could be allowed to increase resilience of plant communities considering climate stressors as new scientific recommendations on native plant tolerances are published.*

- Apply increased protections to bog wetlands and associated buffers to prevent stormwater impacts that could change pH and alter sensitive plant communities.

- Consider adding low impact development or stormwater management requirements to buffer requirements if the jurisdiction does not do so already.

- Encourage use of native plant stock grown under local conditions to increase resilience under climate stressors.*

2.5.2 Wetlands and Drought

Despite expected impacts to wetlands due to climate change, background research and an interview with Ecology staff revealed no implemented planning efforts related to adapting buffer or other regulations in anticipation of drought impacts on wetlands. In Tacoma, it is more likely that forested buffers around wetlands will be affected by drought and extreme heat events.

The draft update to the CAO for the City of Langley incorporates some of the climate change-related guidance found above that was provided to the City by The Watershed Company, though revisions to the draft ordinances appear to be ongoing and no evidence was found that the current (or any) version had been presented to Langley City Council for review.

2.6 Buffer Management

2.6.1 Nearshore and Marine Buffers and Sea Level Rise

2.6.1.1 WSDOE Current Guidance

As the rate of sea level rise will vary greatly across coastal regions of Washington State WSDOE does not provide specific recommended buffer widths in terms of feet or meter lengths for jurisdictions in its current guidance. Instead, WSDOE provides general guidance and recommendations about the ways in which planners and land managers can integrate sea level rise planning into Shoreline Master Programs (SMPs) and land use policies (WSDOE 2017):

- As sea levels rise, so too will the ordinary high water mark (OHWM), which is the basis for determining shoreline jurisdictions. In response, jurisdictions may use sea level rise projections to update the OHWM on planning documents and in regulations.

- High resolution geospatial data of coastal areas has been used in several urban jurisdictions to help identify low-lying areas and to see flooding impacts and different levels of sea level rise. This information can be used by managers to estimate suitable buffer distances based on local topography and risk factors. Similarly, this information can be used to inform future siting requirements for flood control infrastructure, storm drainage facilities, and pump stations.

- In highly urbanized settings, WSDOE recommends jurisdictions use sea level rise projections to establish a setback in order to accommodate future dikes or seawalls that will likely be required to protect existing infrastructure as sea levels rise.

WSDOE recommends that jurisdictions and planners plan for sea level rise by developing sufficient buffers and setback distances. The SMP Handbook includes resources for planners to help make decisions about how and to what degree sea level rise should be incorporated into SMPs. Some of the information included in this handbook comes from the Washington Coastal Resilience Project, which included the development of updated and more accurate sea level rise estimates. WSDOE will be updating SMP guidance to require jurisdictions to address the effects of sea level rise and storm severity in the next few years.

Below are examples of how different jurisdictions have incorporated sea level rise projections into planning and land use policy decisions related to buffers.

2.6.1.2 King County

In 2020, King County established a sea level rise risk area on Vashon and Maury Island during its Comprehensive Plan update. This area extends inland from the edge of the existing 100-year floodplain, and uses sea level rise projections and existing topography to define the risk area. There is not standard buffer width; instead, the width varies depending on local topography and hazards. Under these regulations, new homes built within the risk area are also required to be built three-feet above the 100-year base flood elevation and comply with a number of other floodplain regulations related to home construction. King County selected the three-foot elevation requirement based upon the best available science for sea level rise projections. Additionally, as the buffer area is tied to the FEMA-mapped floodplain, the sea level rise risk area automatically adjusts as FEMA completes floodplain mapping updates.

2.6.1.3 San Juan County

The San Juan County Code requires buffers be of sufficient width to "avoid the need for new protective structural shoreline stabilization and flood protection measures" for the useable life of a structure (assumed to be 75 years) (WSDOE 2021).

2.6.1.4 City of Burien

The City of Burien's SMP includes a policy that directs the City to incorporate updated sea level rise projections in order to update buffer distances and locations as well as other planning decisions.

2.6.1.5 Island County

Island County requires sea level rise projections to be considered during site-specific development in order to create appropriate buffer distances to minimize potential flood risk.

2.6.1.6 City of Edmonds

Edmonds requires the city to evaluate new scientific information related to sea level rise as it becomes available and to update development standards as appropriate.

2.6.1.7 Mason County

When a geotechnical report or assessment is required for proposed structures in Mason County, those reports must address sea level rise. The plans must show the current OHWM and demonstrate that no shoreline stabilization structures will be needed to protect the structure over the course of its anticipated life.

2.6.2 Stream and Riparian Buffers and Climate Change

Riparian buffers provide storage capacity during severe flood events, filter pollutants from stormwater before it reaches streams and rivers, and provide critical habitat. Managing riparian buffers to maximize these benefits is essential in helping jurisdictions adjust to climate change. Several resources exist for resource managers to consider when developing regulations related to riparian buffers.

Past studies have examined recommended buffer widths for riparian areas. In order to be most effective, buffers should extend along all streams including intermittent and ephemeral channels. Buffers as narrow as 4.6 m (15 ft) have proven effective in the short term, although wider buffers provide greater sediment control, especially on steeper slopes. However, long-term studies suggest the need for much wider buffers; 30 m (100 ft) buffers are sufficiently wide to trap sediments under most circumstances, although buffers should be extended for steeper slopes. An absolute minimum width would be 9 m (30 ft). To maintain aquatic habitat, the literature indicates that 10-30 m (35-100 ft) native forested riparian buffers should be preserved or restored along all streams. While narrow buffers offer considerable habitat benefits to many species, protecting diverse terrestrial riparian wildlife communities may require some buffers of at least 100 meters (300 feet) depending on local wildlife conditions. To provide optimal habitat, native forest vegetation should be maintained or restored in all buffers, regardless of size (Wenger 1999).

Although forested buffers provide extensive benefits, both grass and forest buffers can reduce levels of nutrients and sediments from surface runoff and reduce levels of nitrates from subsurface flows. Higher rates of denitrification are often observed in forested buffers, and researchers attribute this to the greater availability of organic carbon and interactions that occur between the forest vegetation and the soil environment. Grass buffers are more quickly established, and in terms of sediment removal, may offer greater stem density to decrease the velocity of water flow and provide greater surface area for sediments to be deposited. Forested buffers, though, offer the advantage that the woody debris and stems may offer greater resistance and are not as easily inundated, especially during heavy floods (Klapproth 1999).

Buffers also provide important benefits in terms of pollutant control. Buffers are short-term sinks for phosphorus, but over the long term their effectiveness is limited. In many cases phosphorus is attached to sediment or organic matter, so buffers sufficiently wide to control sediment should also provide adequate short-term phosphorus control. However, long-term management of phosphorus requires effective on-site management of its sources. Buffers can provide very good control of nitrogen, include nitrate. The widths necessary for reducing nitrate concentrations vary based on local hydrology, soil factors, slope, and other variables. In most cases 30 m (100 ft) buffers should provide good control, and 15 m (50 ft) buffers should be sufficient under many conditions. It is especially important to preserve wetlands, which are sites of high denitrification activity (Wenger 1999).

2.6.2.1 Local Recommendations

In 2023, WDFW developed the RMZ Checklist for CAOs. This tool is intended to be used to determine whether or not existing CAOs contain the most up-to-date and accurate information based upon goals in the GMA and the most recent BAS resources (including Quinn et al. 2020 and Rentz et al. 2020). The document outlines 22 riparian management recommendations, and asks managers whether or not they are included in the CAOs, and how they are or are not addressed. Some information includes:

- Questions about the methodologies used to determine riparian buffers: site-potential tree height, extent of native riparian vegetation, or minimum pollution removal distance.
- Information about the relationship between riparian zones and channel migration zones.
- Inclusion of riverine wetland within buffer areas.

- Mitigation requirements to ensure no net loss of riparian ecological functions.

Specifically, this document also asks planners if their CAO includes language to bolster climate resilience by increasing habitat connectivity, planning for a wider range of streamflows, and increasing stream shading (WDFW 2023).

Snohomish County considers variable buffer widths to allow for greater flexibility in meeting habitat and water quality goals, while reducing impacts to useable lands (Snohomish County 2006). Buffer widths are related to the wetland and riparian functions that need protecting from the upland activities from which a wetland or riparian area is being buffered. Establishing variable buffer widths requires a heightened level of analysis to determine ecosystem functions, and the best decisions to make based on the location of riparian and wetland areas.

In the 2005 Snohomish River Basin Salmon Conservation Plan, buffers of 150 feet were recommended along all salmon bearing streams and rivers. Analyses conducted by the King County Snoqualmie Fish, Farm, Flood Initiative noted the potential for the displacement of hundreds or even thousands of acres of agricultural land in the uniform 150-foot buffer recommendation was implemented. In response, **King County** led an effort to determine priority functions and recommendations for riparian buffer areas in order to more specifically target implementation of the 150-foot buffers as opposed to a one-size-fits-all approach. Although this exercise was targeted specifically on the Snoqualmie River Basin, the results are broadly applicable (Kubo et al. 2019). Findings were grouped into six categories:

Water Quality Control (minimum buffer width: 10-328 ft, minimum buffer length 984-4920 ft):

- Low-gradient areas have higher removal efficacies of suspended solids, nutrients, and pesticides, compared to higher-gradient areas.
- Soils with higher clay content have greater potential for nutrient and pesticide removal.
- Woody vegetation including shrubs and trees have higher removal efficacies of nutrients and pesticides compared to grasses.
- Long and continuous buffers have greater nutrient and pesticide uptake compared to fragmented buffers; narrower buffers that are long and continuous are more effective than wide-fragmented buffers.
- Straightened watercourses require wider, longer, and more continuous riparian buffers to compensate for lost capacity in aquatic in-stream processes.

Water Temperature (minimum buffer width: 5-225 ft, minimum buffer length 328-8202 ft):

- Small and medium watercourses are most susceptible to temperature fluctuations and provide the greatest potential for shading benefits among watercourse sizes.
- Riparian vegetation height and density significantly influence watercourse shading.
- Riparian buffer length accounts for a majority of temperature variation (the longer the buffer length, the greater the shading benefit).

- Narrow-dense riparian buffers are most effective for shading on east-west oriented watercourses.
- Wider-taller buffer widths are needed for shading on north-south oriented watercourses.
- Straightened channels may only require dense and overhanging buffers at relatively narrow widths to provide shade benefits.
- Larger waterways require tall, dense, and wide riparian buffers to shade waterbodies.

Riparian Corridor/Buffer Microclimate (minimum buffer width: 50-328 ft, minimum buffer length: N/A):

- Riparian buffer width, length, and continuity helps protect and maintain microclimate presence from surrounding landscape climate conditions.
- Riparian areas closer to watercourses protect stream center microclimate and riparian areas further from watercourses protect off stream microclimate.
- The ability of microclimate conditions to buffer water temperatures decreases with increasing watercourse width.

Large Wood Recruitment/Retention (minimum buffer width: 13-213 ft, minimum buffer length: N/A):

- Primary wood input among mainstem and large watercourses comes from bank erosion.
- Areas of channel migration require wide buffers to provide continual wood sources.
- Large channels require relatively larger wood (i.e., tall and wide) to remain stable and influence channel and habitat forming processes.
- Coniferous trees provide long-term habitat benefits and deciduous trees provide short-term benefits.
- Armoring shifts wood input drivers from erosion-based to windthrow (trees tipped during large storm events) and tree mortality; large wood source distance from windthrow and mortality is based on max tree height (potential fall distance).
- Size of habitat-forming wood is relatively smaller in small and medium watercourses.
- Small and medium watercourses receive a greater proportion of wood inputs from shorter source distances (closer to watercourses).
- Hardwoods generally contribute more large wood in smaller channels.
- Primary wood inputs among high-gradient watercourses comes from debris flows, landslides, and windthrow (greater source distances than bank erosion).
- High-gradient tributaries contribute to instream wood that is transported downstream.

Erosion and Bank Stability (minimum buffer width: 10-164 ft, minimum buffer length: N/A):

- Trees and shrubs provide the greatest bank stabilization for large watercourses.

- Trees are more effective than shrubs or grasses on steep banks.
- Maximum root strength and depth can be achieved at around ½ site potential tree height.
- Grass and shrubs may be suitable vegetation for small and medium watercourses that have relatively less-steep banks.
- Small and medium channelized watercourses may require trees, rather than grass or shrubs due to related bank steepness.
- Bank erosion commonly occurs on the outside of river bends; outside bends with riparian vegetation can significantly decrease erosion during storm events.
- The denser vegetation is along outside bends, the more effective riparian vegetation is at reducing erosion impacts.

Invertebrate Prey and Leaf-litter Debris Input (minimum buffer width: 10-246 ft, minimum buffer length 164-1969 ft):

- Relative contribution and role of litter and detrital inputs tends to decrease from small streams to large streams.
- Riparian corridor length and continuity may be the primary drivers of macroinvertebrate structure and diversity.
- Percentage of tree coverage in a riparian corridor is positively related to stream invertebrate community structure and diversity.
- Deciduous trees provide seasonal pulse inputs and conifer trees provide year-round inputs.

These findings, in conjunction with spatial data tools and other information, can similarly help the City of Tacoma identify areas in which to prioritize for riparian buffer establishment.

2.6.3 Buffer Restoration and Site Development Standards and Criteria

A review of buffer design and development documents revealed two distinct threads of inquiry: buffer design standards for agricultural lands (Emmingham et al. 2005; Kallestad et al. 2009; Kubo et al. 2019), and buffer design standards for urban areas, particularly with a focus on homeowners (WWCD n.d.; TDADF 2015; KCDNRP n.d.). Aside from these documents, Rentz et al. (2020) provides a list of suggested restoration practices, some of which may be applicable on the scale of an individual urban landowner. None of these documents are regulatory in nature, and largely suggest similar themes deemed important for the function of buffers, such as the use of native plants in appropriate microclimates, co-benefits for property owners who plant native riparian buffers, and overviews of buffer functions. For the purposes of this section, the focus is primarily on buffer design standards for urban areas.

Chapter 4 of the Management Recommendations included in the 2020 Riparian Ecosystems Guidance from WDFW includes a series of restoration actions that has been included below (Rentz et al. 2020).

- Improve quality of vegetation for both aquatic and terrestrial wildlife by removing invasive species wherever present. Further, to avoid the likely return of invasive species, cleared areas should be replaced with native riparian vegetation: specifically, native vegetation that provides needed ecosystem functions as described in Volume 1 and throughout this document (e.g., shade, large wood, pollution removal).

- Where riparian areas already possess some native vegetation, enhance them with a greater mixture of native plants that provide necessary habitat components (forage, cover, breeding, roosting, etc.) for a diversity of species and multiple riparian functions (e.g., streambank stability, wood recruitment, organic litter input, and pollutant removal). The specific mix of vegetation will vary by ecoregion and local needs, but likely includes conifers, grasses, and herbaceous plants.

- Increase off-channel habitat and improve natural flow regimes by removing dikes or levees and restoring access to and within the floodplain.

- In areas of incised channels, reintroduce beaver or construct beaver dam surrogates to store sediments, raise streambed elevation, raise water table elevation, and restore riparian vegetation.

- Remove reed canary grass, which can greatly inhibit channel morphology and aquatic species movement.

- Through proper consultation with WDFW and tribal biologists, increase the presence of large wood in streams and rivers to improve habitat for salmon, resident fish species, and aquatic amphibians.

- Increase connectivity through removal of non-fish passing culverts. If replacement culverts are needed, ensure they are adequately sized and climate-change-resilient; see WDFW's online resource on Incorporating Climate Change into the Design of Water Crossing Structures (Wilhere et al. 2016).

- Reduce soil erosion by increasing vegetation complexity and density, excluding (or substantially minimizing) soil compacting activities, and implementing upland soil management techniques where applicable.

The **Walla Walla Conservation District** (WWCD) has developed the Creating Urban Riparian Buffers (CURB) program with the intent of improving water quality and wildlife habitat in streams that flow through Walla Walla and College Place. In their guidance document titled *Do-It-Yourself Riparian Buffer Guide for Homeowners*, WWCD lays out a decision pathway for property owners, supporting the identification of challenges such as noxious weeds, erosion, and sediment accumulation before guiding property owners through the likely resolutions to these challenges. The guide includes design recommendations and a plant list comprised of appropriate native species (WWCD n.d.).

King County Department of Natural Resources and Parks published a brochure guiding property owners through the benefits and planning requirements of installing a native plant buffer. This includes a suggested site plan, plant lists for each microclimate expected in a riparian area, a seasonally indexed planting and design guide, and an overview of required permits for work performed in the stream buffer (KCDNRP n.d.).

2.6.4 Plant Lists for Western Washington Riparian Buffers

Tables 3 and 4 present recommended riparian buffer plant lists from KCDNRP and the Riparian Buffers for Western Washington Agriculture (Kallestad et al. 2009). Table 3 includes consideration of species and associated climate-related concerns.

TABLE 3. KCDNRP RIPARIAN PLANT LIST AND CLIMATE CHANGE-RELATED CONCERNS

Planting Site	Plant Species		Example Climate Change-Related Concerns
Wet, Saturated conditions	• Oregon ash • Pacific crabapple • Sitka spruce • Black cottonwood • Red-osier dogwood	• Lady fern • Rushes • Bulrushes • Arrowhead • Bur-reed • Cattail	• Oregon ash – low drought tolerance, susceptible to emerald ash borer • Pacific crabapple – moderate drought tolerance, high flood tolerance • Sitka spruce – low drought tolerance • Black cottonwood –low drought tolerance
Moist or inundated slopes	• Pacific ninebark • Swamp rose • Salmonberry • Snowberry • False lily-of-the-valley • Sedges	• Red alder • Shore pine • Cascara • Native willows • Western red cedar • Twinberry	• Shore pine – high drought tolerance • Cascara – moderate drought tolerance • Western red cedar –low-moderate drought tolerance; largely pest- and disease-resistant • Red alder – moderate drought tolerance
Dry, upland slopes	• Baldhip and Nootka roses • Thimbleberry • Elderberry • Sword fern • Douglas fir	• Vine maple • Bigleaf maple • Serviceberry • Black hawthorn • Salal • Oceanspray	• Douglas fir – moderate-high drought tolerance; susceptible to beetle infestations in warming conditions • Bigleaf maple – moderate drought tolerance; low-moderate tolerance of warming temperatures • Black hawthorn – moderate drought tolerance, high flood tolerance • Vine maple – low-moderate drought tolerance
SOURCE: KCDNRP n.d.			

TABLE 4. WESTERN WASHINGTON AGRICULTURE PLANT LIST (KALLESTAD ET AL. 2009).

Planting Site	Trees and shrubs	Understory
Streamside	• *Salix scouleriana* (Scouler's widow) • *Salix sitchensis* (Sitka willow) • *Salix lasiandra* (Pacific willow) • *Cornus cerulea* (Red-osier dogwood) • *Alnus rubra* (Red alder) • *Thuja plicata* (Western red cedar) • *Picea sitchensis* (Sitka spruce) • *Rubus spectabilis* (Salmonberry) • *Ribes lacustre* (Prickly currant) • *Spirea douglasii* (Spirea hardhack)	• *Oxalis oregano* (Wood sorrel) • *Polystichum munitum* (Sword fern) • *Athyrium filix-femina* (Lady fern)

Upslope	• *Pseudotsuga menziesii* (Douglas fir) • *Tsuga heterophylla* (Western hemlock) • *Populus trichocarpa* (Black cottonwood) • *Acer macrophyllum* (Bigleaf maple) • *Fraxinus latifolia* (Oregon ash) • *Acer douglasii* (Douglas maple) • *Symphoricarpos albus* (Snowberry) • *Rosa spp.* (Wild rose)	

SOURCE: Kallestad et al. 2009

2.6.5 Buffer Maintenance Standards and Criteria

No Washington-specific sources of buffer maintenance recommendations were located, though some of the management activities from Rentz et al. (2020) could be construed as such. A nationwide search for buffer maintenance guidance resulted in the identification of three resources in addition to the maintenance suggestions included above.

Created by the Tennessee Department of Agriculture Division of Forestry (TDADF), the *Tennessee Urban Riparian Buffer Handbook: A Practical Guide to Establishing Healthy Streamside Buffers* is intended to support property owners, local governments, and community groups in advancing the creation of riparian buffers. The guide includes a scoresheet for identifying sites in need of buffer enhancement, suggestions related to buffer landscape design including access and scenic considerations, and several example site plans for a variety of land use types including residential, parkland, and commercial properties. The document provides a local native plant list, as well as suggestions related to the number of plants to be included in a buffer of a given size (TDADF 2015):

- Inform your neighbors to assuage concerns that may arise around the appearance of property neglect.
- Avoid mowing in a planted buffer. Where mowing is required such as along footpaths, do not mow lower than 4-6 inches.
- Periodic removal (2x a year) of volunteer nonnative invasive species is recommended.
- For buffers installed on properties maintained by landscaping crews, the use of fences and no-mow signage during the first several years of buffer establishment may be necessary. Fences may also be an opportunity to mount signage or other resources explaining to the broader public the benefits of riparian buffers.

In Harrisonburg, Virginia, the *Stream Buffer Maintenance Handbook for Newly Established Buffers* gives guidance related to riparian buffers on private residential properties as well as on lands where the public may be allowed. They indicate that the first 3-5 years after planting a buffer are the most important maintenance period and suggest the following activities (City of Harrisonburg 2011):

- If used, maintain tree shelters to support the establishment of trees and prevent grazing.

- Utilize hand pulling or limited pesticides to abate weed growth, limiting mowing to target weed species during appropriate seasons during years one and two, taking care to avoid nesting periods.

- Replant and reseed the buffer as needed throughout the first few years to replace plants and trees that have died.

- Inspect the buffer annually, and after major storms. Ensure that any dead or damaged plants are replaced in a timely manner.

- No-mow zones, signage, and fencing are also recommended as options to support the establishment of a riparian buffer.

In a 1999 review of forest riparian buffer design and management, appropriate maintenance activities are identified, of which the following may be applicable for an urban riparian buffer (Klapproth 1999):

- Landowners should inspect the buffer on a regular basis, watching for bank erosion and washouts, weed problems, wildlife damage, and insect and disease problems.

- Mulching and landscape fabrics may be used to avoid the establishment of weeds.

- Once a stand of trees has become established, periodic thinning and harvest of select trees can help to maintain vigorous growth and maximize nutrient uptake.

- At maturity, selective harvest of trees is recommended to sustain this growth and to remove nutrients sequestered in tree stems and branches.

- Where warm season grasses are used in a buffer design, they may require particular attention while establishing as they will be vulnerable to competition from weeds while they establish root networks.

- In some cases, a berm of sediment may develop along the edge of a buffer. This should be removed if and when it reaches six inches in height and the area around it should be regraded and reseeded.

2.6.6 Regulations Requiring Bulkhead Removal

Across all jurisdictions whose SMPs were reviewed in the process of creating this document, no active SMP was found to have a standard or regulation requiring the removal of bulkheads. The **City of Issaquah** may become the sole exception, as their current draft SMP has provisions that would require the removal of structural bulkheads upon (re)development unless an appropriate geotechnical report prepared by the applicant finds that such a structure would be required to retain use of the property. In such a case, it would be required that the design of the shoreline armor be such that it accounts for likely negative ecological impacts of shoreline armor and seeks to address them. Elsewhere, the draft SMP restricts the construction of new bulkheads where one is not currently in place.

An interview with planning staff in Issaquah conferred that WSDOE staff who are currently reviewing the document seemed “hesitant” about some of the language being used in the draft SMP related to bulkhead removal. This is likely owing to the fine line that must be walked when disallowing structural armoring such as bulkheads so that a taking does not occur. The draft is expected to be returned to Issaquah in July 2023 and should be monitored to determine if WSDOE is supportive of restrictions on shoreline armoring at this level.

2.6.7 Lessons Learned for Tacoma

The **City of Issaquah** uses the percentage of a buffer comprising nonnative invasive species as the standard for requiring enhancement of the buffer upon site (re)development. When a buffer area consists of more than 50% nonnative invasive vegetation, enhancement will be required. It was suggested during an interview that the reason they can require such a standard is because of engaged citizens and advocacy groups who often push the City to "do more" with regards to environmental protection. It was reported that many developers have willingly enhanced buffers to win community support for projects, highlighting the importance of strong public engagement in advancing environmental protections and associated regulations.

CHAPTER 3
Shoreline Master Programs

This section reviews if and how sea level rise has been integrated into Washington municipalities' Shoreline Master Programs, where and how soft shore stabilization techniques have been encouraged and/or used in place of hard armoring, and climate adaptation case study summaries from other port cities in the United States and Canada.

3.1 Sea Level Rise Integration into Shoreline Master Programs

3.1.1 Summary

Addressing sea level rise in Shoreline Master Programs (SMPs) is not currently required, though guidance for doing so electively is included in Appendix A of WSDOE's SMP Handbook (WSDOE 2017). With the passage of House Bill 1181 – *Improving the state's response to climate change by updating the state's planning framework* – in the 2023 legislative session, WSDOE has been directed to update SMP guidance to require programs to address the effects of sea level rise and storm severity on "people, property, and shoreline natural resources and the environment." While the law goes into effect on July 23, 2023, these requirements are unlikely to apply immediately (Andrews 2023).

The general approach to incorporating sea level rise into SMPs in jurisdictions that have done so to date includes:

1. *Acknowledging sea level rise as a problem/monitoring objective either in the Comprehensive Plan or a SMP*: Because there is not yet an enforceable mandate to plan for sea level rise, this step is important to provide grounds for regulatory controls related to sea level rise. These policies can also guide internal discussion though they lack the quantified and enforceable requirements updated regulations provide.

2. *Performing a localized sea level rise vulnerability or risk assessment and/or electing to utilize models developed by the Washington Coastal Resilience Project (Miller et al. 2018) to evaluate local sea level rise risks*: Because most sea level rise projections are presented probabilistically (as a percent chance of occurring between 0.1–99%), determining which emission scenario(s) to use and overall risk tolerance is an important part of this step for individual jurisdictions. RCP 8.5 is a high-emissions scenario in which greenhouse gas emissions continue unabated while RCP 4.5 assumes more stringent global enforcement of emissions reductions. High-likelihood projections reflect lower rates of sea level rise and may be easily exceeded while low-likelihood projections reflect higher rates of sea level rise that are within the realm of possibility but are less likely to occur. Mid-range projections (between 17–83%) under the RCP 8.5 scenario typically address the average concerns and risk tolerance of many jurisdictions to evaluate risk under the most likely conditions to occur by a given timeframe (e.g., 2050, 2080, 2100, etc.). For example, a project to redesign Owen Beach at Point Defiance Park adopted a 17% probability of 2.5 feet of inundation

by 2090 under a high emissions scenario (RCP 8.5) along with around 3.6 ft of storm surge as their scenario (Faghin n.d.). The associated sea level rise rates were then incorporated into the project design to ensure park structures and facilities remained functional through their anticipated lifespans. Guidance on how to choose appropriate sea level rise projections is included in Appendix A of the SMP Handbook.

3. *Developing and adopting regulations and requirements based on local vulnerabilities*. Several examples are included below from different cities and counties in Washington.

Most jurisdictions addressing sea level rise are somewhere between steps one and two, with a select few (e.g., **Olympia**, **Langley**, **Bellingham**) moving forward in some capacity based on modelling available to them. Other jurisdictions are in the process of or waiting to begin modelling (e.g., **Grays Harbor**) and have created some policy-level guidance in their SMPs to support the adoption of regulatory provisions later. Some jurisdictions have added small regulatory allowances or restrictions to address some component of sea level rise (e.g., building elevation in **Pierce County**, anticipation of bluff erosion in **San Juan County**) without fully addressing sea level rise challenges across the board.

Topics addressed in cataloged SMPs:

- Bluff erosion
- [Dis]allowance of hard-structure shoreline armoring/protection
- Changes in recreational access to beaches or intertidal zones
- Decrease in nearshore habitat
- Accommodation of shoreline migration
- Elevation of existing structures (and the intersection of those activities with height limits)
- Shifting shoreline jurisdiction boundaries
- Stormwater outfalls
- Implications for restoration projects/mitigation activities
- Siting of new roadways, railways, or other public facilities

Challenges to adoption of sea level rise regulations in SMPs were collected by the WSDOE in the report titled: *Lessons Learned from Local Governments Incorporating Sea Level Rise in Shoreline Master Programs* (WSDOE 2021). These included:

- Pressure for residential development in areas vulnerable to sea level rise.
- Existing development in vulnerable areas where it is difficult or impossible to relocate (e.g., railroads and wastewater treatment sites).

- Concerns over regulations affecting private property.
- Uncertainty regarding legal liability stemming from action (or inaction) on sea level rise.
- Potential legal risks and liabilities when sharing sea level rise data and information.
- Insufficient capacity to take on mandatory planning work, leaving little staff time available for the development of voluntary initiatives such as sea level rise regulations.
- Disconnect between long-range planners and those who implement SMPs resulting in unclear guidance related to sea level rise policies where regulations are not in place.
- Uncertainty around future conditions requiring decisions about risk tolerance.

3.1.2 Implementation Examples

3.1.2.1 King County

In King County, the sea level rise risk areas is defined as three feet above the base flood elevation identified in the 2020 Flood Insurance Rate Map for the adjacent coastal high hazard area flood zone and only applies to Vashon-Maury Island. Reference to the sea level rise protection zone and risk area appear in regulations regarding steep slopes, groundwater wells, and shoreline stabilization. Steep slopes and groundwater wells within sea level rise areas are subject to additional regulatory requirements while new development or redevelopment on the island triggers the suggestion that structures be setback further than the recommended amount by the developer (Title 21A).

21A.24 Critical Areas

- Steep slope hazard areas: "For new structures and substantial improvements to existing structures on sites where any portion of the steep slope hazard area extends into the coastal high hazard area or sea level rise risk area: a) The critical area report shall include an assessment of current and future risks of sea level rise conditions anticipated to occur over the next fifty years and a recommended buffer; b) If a critical area report is not submitted to the department, the minimum buffer shall be seventy-five feet."
- Critical aquifer recharge areas on Vashon-Maury Island: "All new groundwater wells within a sea level rise risk area shall include a surface seal that prevents risks of saltwater contamination caused by sea level rise conditions anticipated to occur over the next fifty years; and [t]he owner of a new well located within the sea level rise risk area shall test the well for chloride levels using testing protocols approved by the Washington State Department of Health. The owner shall report the results of the test to Seattle-King County Department of Public Health and to the Department of Natural Resources and Parks. If the test results indicate saltwater intrusion is likely to occur, the Department of Natural Resources and Parks, in consultation with Seattle-King County Department of Public Health, shall recommend appropriate measures in addition to the minimum requirements of this title to prevent saltwater intrusion."

21A.25 Shorelines

- Shoreline stabilization: "The department shall provide a notice to an applicant for new development or redevelopment located within the shoreline jurisdiction on Vashon and Maury

Island that the development may be impacted by sea level rise and recommend that the applicant voluntarily consider setting the development back further than required by this title to allow for future sea level rise."

3.1.2.2 Bellingham

The Bellingham SMP includes recognition that as sea level rise projections become adopted by the scientific community, they can be applied to planning efforts and development standards in Bellingham (Title 22). For the purposes of determining OHWM and other jurisdictional boundaries, the likely impacts of sea level rise are acknowledged and addressed by a requirement that such boundaries be determined by field investigations and a survey or engineered drawings.

22.03.010 Shoreline jurisdiction

- "Natural or restored shoreline ecosystems and processes that occur over time, such as channel migration or sea level rise, have the potential to alter the point of beginning (OHWM, outer extent of a floodway, floodplain or channel migration zone) from which the extent of shoreline jurisdiction is measured."

22.03.030 Shoreline environment designations

- "*Setbacks and Buffers.* Development within shoreline reaches designated as shoreline residential shall be set back from the field-determined OHWM (approximately elevation 314 feet above sea level) of the shoreline."

3.1.2.3 San Juan County

San Juan County requires that on all non-bedrock shorelines, new structures must evaluate the potential impacts of sea level rise over the life of the structure (defined as 75 years) and demonstrate that the proposed buffer will be sufficient to avoid the need for new protective structural shoreline stabilization and flood protection measures for that period. No citation was given for the 75-year building life and the SMP update precedes the release of the Miller et al. (2018) projections.

3.1.2.4 Jefferson County

Jefferson County's SMP includes a policy that "encourages" all shoreline use and development to address potential impacts of climate change and sea level rise (Title 18):

18.25.180 Shoreline use

- "Encourage all shoreline use and development to address potential adverse impacts of global climate change and sea level rise."

3.1.2.5 Burien

Burien has a goal to monitor sea level rise and adjust development standards accordingly (Title 20):

20.20.045 Flood prevention and minimization element

- "Monitor sea level rise and accordingly adjust development standards and building setbacks to minimize flooding potential."

3.1.2.6 Olympia

The mention of sea level rise impacts in Olympia's SMP largely references the 2019 Sea Level Rise Response Plan developed for the downtown area:

SMP goals and policies

- "The City should…develop plans to address the impacts of sea level rise in collaboration with impacted property owners, the community and the [WSDOE]. These plans should include at minimum flood prevention approaches, shoreline environment impact considerations and financing approaches. The City should amend the [SMP]and other policy and regulatory tools in the future as necessary to implement these plans."

- "The City should collaborate with private property owners, business owners and citizens in the implementation of the [SMP]to explore creative ways to reduce ecological impacts and mitigate for impacts from sea level rise when new development or redevelopment is proposed. This objective may best be accomplished by developing flexible approaches to shoreline development where the total environmental benefit is enhanced through such measures."

- "Residential development, including the division of land and the construction of residential units, should be designed and located with consideration of sea level rise projections and so that shoreline armoring and flood hazard measures will not be necessary to protect land or structures."

- "New development requiring structural shoreline armoring should not be allowed. Shoreline use and development should be located and designed in a manner so that structural stabilization measures are not likely to become necessary in the future, including a consideration of sea level rise."

18.20.837 Fill water-ward of the OHWM

- "Construction of protective berms or other structures to prevent the inundation of water resulting from sea level rise shall be allowed subject to all other provisions of this [SMP]and the mitigation sequencing process when there are no other feasible options to protect existing development."

3.1.2.7 Pierce County

Pierce County has updated its SMP to allow for structural raising of legally established single-family residences and nonconforming structures to protect the structures from sea level rise in accordance with the height limits established elsewhere in the County Code (Title 18):

18s.10.055C Residential structures

- "Structurally raising the floor elevation of an existing legally established single-family residence, which is necessary to protect the structure from flooding due to sea level rise, shall be allowed in accordance with the height limits set forth in PCC 18S.30.060, Scenic Protection and Compatibility."

3.1.2.8 Langley

The Langley SMP includes many provisions related to sea level rise that rely on the 2021 City of Langley Sea Level Rise Assessment:

4.2 Shoreline use

- "The City should continue to develop information about the impacts of sea level rise on the shoreline and other affected properties; the City should develop adaptation plans to address the impacts of sea level rise in collaboration with impacted property owners, the community and the [WSDOE]. These plans should include at minimum flood prevention approaches, shoreline environment impact considerations and financing approaches. The City should amend the [SMP] and other policy and regulatory tools in the future as necessary to implement these adaptation plans."

- "During scheduled SMP updates, the City shall assess whether the anticipated sea level rise projections used in the SMP remain relevant or revisions are necessary to adjust for more up to date research."

- "Applicants for development in the shoreline plan area shall be provided with information on sea level rise."

- "Applicants for development in Langley's West and Center reaches shall be encouraged to voluntarily consider increasing setbacks to allow for future sea level rise."

- "A condition of approval for any application, including an exemption letter, shall be required to record a notice on title to identify the potential threat associated with sea level rise and shall hold the City harmless."

- "Geotechnical reports in support of variances proposing development or redevelopment within 65 feet of a bluff must contain erosion projections for 75 years based in part on sea level rise."

4.4 Flood hazard management

- "When reviewing projects that could be affected by sea level rise adjust development standards such as building setbacks or elevation as necessary to minimize potential damage from flooding."

4.5 Public access

- "Public access sites shall be designed to accommodate for the level of expected sea- level rise in 2100. Consideration of sea level rise projections …may be used."

5.1 Shoreline stabilization

- "Partial modification of stabilization measures (e.g., fill, construction of protective berms) within the shoreline jurisdiction shall be allowed in response to increases in sea level, subject to all other provisions of the SMP."

- "The size of the shoreline stabilization structures shall be the minimum necessary to protect the primary use or structure. Consideration of sea level rise projections … may be used to determine the minimum necessary size of shoreline stabilization structures."

- "The size of the bulkhead shall be the minimum necessary to protect the primary use or structure. Consideration of sea level rise projections … may be used to determine the minimum necessary size of shoreline stabilization structures."

6.10 Utilities

- "Upgrades and replacement of utilities and other public infrastructure shall be located outside of areas that may be impacted by the expected sea-level rise in 2100. If infeasible, such development shall be designed and constructed to adapt to the level of expected sea level rise feet in 2100. Consideration of sea level rise projections "

3.1.2.9 Ocean Shores

Ocean Shores requires that structures be set back from steep slopes and shorelines vulnerable to erosion so that structural improvements are not required to protect such structures for the expected life of the structure, including anticipated impacts from sea level rise. No expected structure life or sea level rise projection is given in the SMP.

5.14 Residential development

- "Set back residential development and accessory structures and uses from steep slopes and shorelines vulnerable to erosion so that structural improvements are not required to protect such structures for the expected life of the structure and considering sea level rise, increased storm intensity, and changes to coastal erosion and sediment supply."

3.1.2.10 Port Angeles

The Port Angeles SMP requires geotechnical reports for projects requiring variances within 65 feet of a bluff, which include 75 years of anticipated sea level rise impacts utilizing best available science.

5. Critical areas (geologically hazardous areas)

- "Proposals requiring a variance for development within 65 feet of the top of a marine bluff as outlined above shall be required to submit a geotechnical engineering report, prepared in accordance with the requirements of this SMP. The geotechnical engineering report shall: include coastal erosion rates over at least 75 years, based in part on anticipated sea level rise and storm frequency"

3.1.2.11 South Bend

In South Bend, new structural stabilization is prohibited except when a geotechnical report identifies the need to protect existing primary structures from impacts borne in part of sea level rise or natural processes. Existing armoring may be replaced only under similar circumstances:

5.7 Shoreline stabilization

- "New structural shoreline stabilization measures shall not be allowed except when necessity is demonstrated…to protect existing primary structures [and] there is conclusive evidence, documented by a geotechnical analysis that the structure is in danger from shoreline erosion caused by tidal action, currents, waves, or sea level rise. Normal sloughing, erosion of steep bluffs, or shoreline erosion itself, without a scientific or geotechnical analysis, is not demonstrated need. The geotechnical analysis should evaluate on-site drainage issues and address drainage problems away from the shoreline edge before considering structural shoreline stabilization."

- "A property owner may replace an existing shoreline stabilization structure with a similar structure if there is a demonstrated need to protect primary uses or structures from erosion caused by currents, tidal action, waves, or sea level rise. Replacement may occur in accordance with the following provisions:

  - The design, location, size, and construction of the replacement structure results in no net loss of shoreline ecological functions;

  - Replacement walls or bulkheads do not encroach waterward of the OHWM or existing structure unless the residence was occupied before January 1, 1992 and there is significant safety or environmental concern. In such cases, the replacement structure shall abut the existing shoreline stabilization structure;

  - Where a net loss of shoreline ecological functions associated with critical saltwater habitats would occur by leaving the existing structure, remove it as part of the replacement measure; and

  - Replacement of structural stabilization measures with nonstructural ones that restore shoreline ecological functions may locate waterward of the OHWM."

3.1.2.12 University Place

University Place allows fill to be placed waterward of the OHWM to create protective berms or other structures in response to sea level rise (Chapter 18):

18.35 Shoreline modifications

- "Fill should be allowed to accommodate berms or other structures to prevent flooding caused by sea level rise when other flood prevention methods or alternatives are not feasible and in accordance with UPMC 18.25.030."

- "Fill waterward of the OHWM shall be authorized for the following purposes only, with due consideration given to specific site conditions and only as part of an approved use or development…Construction of protective berms or other structures to prevent the inundation of water resulting from sea level rise when consistent with the flood hazard reduction provisions in UPMC 18.25.030."

3.1.2.13 Clallam County

Clallam County requires the consideration of sea level rise impacts in the location and design of roadways and other infrastructure, designing shoreline stabilization, and as a rationale for establishing buffers. Its SMP does not quantify sea level rise risks (Title 35).

35.05 SMP goals

- "To increase public awareness of sea level rise projections, and tsunami hazard areas and evacuation route maps in coastal areas."

- "To inform citizens and property owners about information on potential climate change and sea level rise impacts..."

35.15 Transportation policies

- "The location and design of new transportation uses/developments including replacement of existing roads and other infrastructure should take into account implications of sea level rise and other climate change effects."

35.30 Shoreline buffers and vegetation conservation

- "Buffers should be established and maintained along all marine and freshwater shoreline water bodies to protect people and property from risks associated with flooding, bank erosion, channel migration, bluff recession, landslides, storm surges, sea level rise, tsunamis and other hazards."

3.2 Soft Shore Stabilization Examples in Washington

3.2.1 Alternatives to Bulkheads

WSDOE's SMP guidelines encourage the use of soft shore stabilization techniques over hard armoring (e.g., bulkheads, seawalls) to provide protection while limiting erosion and habitat degradation. Engineered soft shore designs are characterized by the use of natural features such as drift logs, vegetated berms, beach nourishment, and large rocks to mimic naturally occurring ecological processes while still providing protection to landward resources and structures. WSDOE maintains a database of soft shoreline projects here.

Some examples of soft shoreline projects include:

- ***Sunlight Shores, Whidbey Island***: An old bulkhead comprising concrete, creosote-soaked wood pilings, and boulders was replaced with a natural shoreline, returning beach access to residents and protecting upland property from erosion risks and sea level rise.

- ***Powell Property, Bainbridge Island***: A residential property whose beach was bordered by concrete bulkheads, rock walls, and creosote-treated wood pilings deployed a soft-shore design that incorporated native plants and now provides habitat for a number of marine species including Chinook salmon.

- ***Seahurst Park, Burien***: In partnership with the U.S. Army Corps of Engineers, the City of Burien restored the shoreline within the boundaries of Seahurst Park through the removal of hard shoreline armor, riparian habitat enhancement, and the relocation of park facilities. To remedy the observed drop in beach level due to unreplaced sediment since the construction of hard armor, the new beach was nourished by the addition of gravels.

- ***Edgewater Beach, Olympia***: In partnership with the South Puget Sound Salmon Enhancement Group, a private property owner on Edgewater Beach removed ~800 feet of armoring from the base of a feeder bluff, allowing the sediment supply from the feeder bluff to enter the system and restore beaches that had been deprived of sediment supply.

3.2.2 Site Identification

Several organizations including the Puget Sound Partnership and WDFW have been involved in projects facilitating the removal of hard shoreline armoring in Puget Sound. Of projects completed to date and reviewed in the development of this summary, recreational and residential land uses appear to be most

accommodating to armor removal projects, largely due to the flexibility inherent in sites developed for these uses. In all cases however, site-specific characteristics are most important in determining suitability for armor removal and all guidance reviewed encourages a site-by-site approach to designing projects.

While no decision support tools were identified to aid in the selection of sites, several criteria emerged as being important to the overall function of the nearshore ecosystem in Puget Sound. Examples of this include ensuring the function of feeder bluffs to enable adequate sediment supply, expanding or extending sites that already support habitat to further redevelop ecological function, or utilizing drift cells or other geological markers to identify sites that substantially limit ecological function or who may contribute substantially if restored.

Released in 2014, the WDFW Marine Shore Design Guidelines set out to establish the characteristics that support different shoreline armoring designs on a given site including the identification of sites where hard armor is the only viable solution (Johannessen et al. 2014; Figure 1).

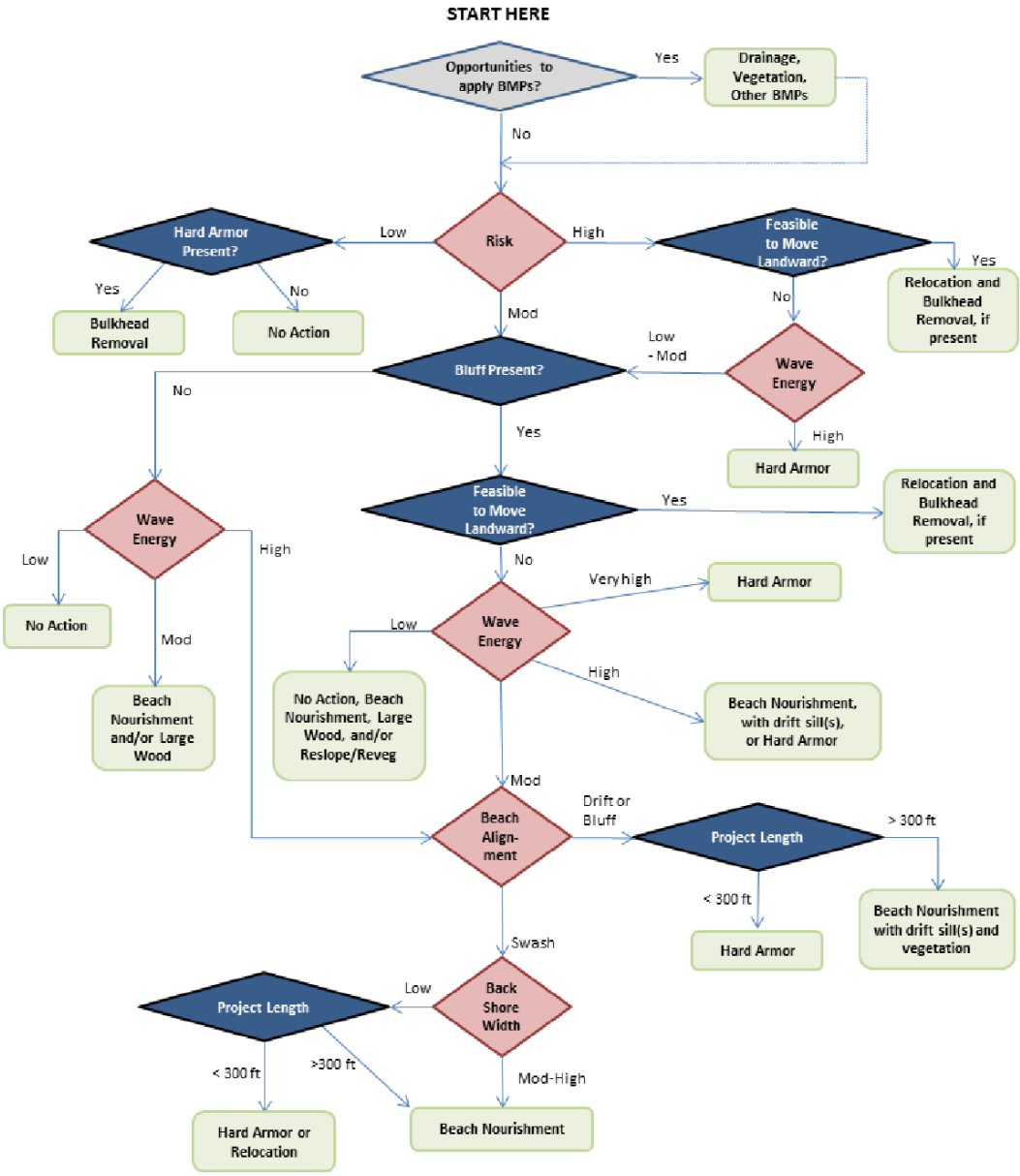

Figure 5-11. Decision tree for identifying appropriate design techniques for a given site. Read top to bottom. Refer to site and coastal processes assessment data, Table 3-4 for risk, Tables 5-6 for wave energy, and 5-7 for backshore width categories.

SOURCE: Johannesen et al. 2014

Figure 1
WDFW Marine Shoreline Design Guidelines Shore Armor Decision Tree

Similarly, the Seattle Green Shoreline Decision Tree (City of Seattle n.d.) was designed for Lake Washington. The graphic is included here as an alternative presentation method to the decision tree presented in Johannessen et al. (2014), which could be further modified to address site or sub-area specific conditions along Tacoma's shorelines (Figure 2).

SOURCE: City of Seattle n.d.

Figure 2
Seattle Green Shoreline Decision Tree

3.2.3 Standards, Criteria, and Definitions

3.2.3.1 Shoreline Management Act

The Shoreline Management Act requires that hard armoring approaches such as bulkheads be viewed as a last resort option when all other designs have been deemed infeasible (Carman et al. 2010). In cases where hard armoring is unavoidable, it is suggested that jurisdictions search for opportunities to minimize and mitigate the site-specific and cumulative impacts of that project (EnviroVision et al. 2010). One

example is the design of the Elliott Bay seawall in Seattle, which includes light-penetrating sidewalks, riparian zones, and an underwater habitat bench to create a shallow water corridor for migrating salmon (Dunagan 2020). It is recommended that guidance products and technical assistance be provided to contractors and homebuyers regarding the benefits of soft shore techniques in terms of expense, complexity, long term resilience, and ecosystem function (Dethier et al. 2017) to further support the removal of hard shoreline armoring.

Two examples of SMPs that are noteworthy for the way they handle soft shore stabilization projects are Island County and Whatcom County.

Island County

Island County allows for the modification of shoreline buffers and setback requirements to encourage shoreline restoration projects:

- "If a property owner removes existing structural shoreline stabilization and replaces it with natural soft shore stabilization in accordance with Army Corps of Engineers and National Marine Fisheries Service standards for shoreline restoration, the standard shoreline buffer (or setback in the Canal Communities) may be reduced by a distance equal to the distance that the [OHWM] is moved toward the principal structure on the site following removal of the structural stabilization, up to fifty percent (50%) of the required buffer width."

Island County also has a host of requirements related to the conservation of shoreline vegetation including the requirement that native plants typical of the area be used in restoration projects, protecting existing native vegetation and natural features such as stumps and drift logs, and pruning restrictions, among others.

Whatcom County

In addition to requirements stating that non-structural shore protection measures should be pursued, Whatcom County establishes a hierarchy for stabilization designs:

- "Structural shoreline stabilization measures should only be used when more natural, flexible, nonstructural methods such as vegetative stabilization, beach nourishment and bioengineering have been determined infeasible. Alternatives for shoreline stabilization should be based on the following hierarchy of preference: a. No action (allow the shoreline to retreat naturally), increase building setbacks, and relocate structures. b. Flexible defense works constructed of natural materials including soft shore protection, bioengineering, including beach nourishment, protective berms, or vegetative stabilization. c. Rigid works constructed of artificial materials such as riprap or concrete."

Construction setbacks have been noted as the most effective tools for shoreline protection (Barnard 2010).

3.2.3.2 Guidance

The Puget Sound Nearshore Ecological Restoration Program (PSNERP) partnered with WDFW to release *Management Measures for Protecting and Restoring the Puget Sound Nearshore* (Clancy et al. 2009). This document provides a menu of management options for restoring ecological function to the nearshore environment in Puget Sound. It includes 21 management measures, including armor removal and modification, beach nourishment, large wood placement, and revegetation. Each of these management

measures is described in detail, including performance measures that could be monitored once a project is implemented. Table 5is taken from the document and describes each of the management measures. Each measure is explored in further detail within the document.

TABLE 5. PSNERP MANAGEMENT MEASURES FOR PROTECTING AND RESTORING THE PUGET SOUND NEARSHORE.

No.	Management Measure	Description
1	Armor Removal or Modification	Removal, modification, or relocation of coastal erosion protection structures such as rock revetments, bulkheads, and concrete walls on bluff-backed beaches, barrier beaches, and other shorelines.
2	Beach Nourishment	The intentional placement of sand and/or gravel on the upper portion of a beach where historic supplies have been eliminated or reduced.
3	Berm or Dike Removal or Modification	Removal or modification of berms, dikes and other structures to restore tidal inundation to a site that was historically connected to tidal waters. Includes dike/berm breaching and complete dike/berm removal.
4	Channel Rehabilitation or Creation	Restoration or creation of cannels in a restored tidal wetland to change water flow, provide habitat, and improve ecosystem function.
5	Contaminant Removal and Remediation	Removal or remediation of unnatural or natural substances (i.e. heavy metals, organic compounds) harmful to the integrity or resilience of the nearshore. Pollution control, which is a source control measure, is a different measure.
6	Debris Removal	The removal of solid waste (including wood waste), debris, and derelict or otherwise abandoned items from the nearshore.
7	Groin Removal or Modification	Removal or modification of groins and similar nearshore structures built on bluff-backed beaches or barrier beaches in Puget Sound.
8	Habitat Protection Policy or Regulations	The long-term protection of habitats (and associated species) and habitat-forming processes through zoning, development regulations, incentive programs and other means.
9	Hydraulic Modification	Modification of hydraulic conditions when existing conditions are not conducive to sustaining a more comprehensive restoration project. Hydraulic modification involves removing or modifying culverts and tide gates or creating other engineered openings in dikes, road fills, and causeways to influence salt marsh and lagoon habitat. This measure is used in managed tidal systems (as opposed to naturally maintained systems).

10	Invasive Species Control	Eradication and control of nonnative invasive plants or animals occupying a restoration site and control measures to prevent introduction of such species after construction is complete.
11	Large Wood Placement	Installation of large, unmilled wood (large tree trunks with root wads, sometimes referred to as large woody debris) within the backshore or otherwise in contact with water to increase aquatic productivity and habitat complexity.
12	Overwater Structure Removal or Modification	Removal or modification of overwater structures such as piers, floats and docks to reduce shading and restore wave regimes.
13	Physical Exclusion	Installation of exclusionary devices (fences, barriers, mooring buoys, or other devices) to direct or exclude human and/or animal use of a restoration site.
14	Pollution Control	Prevention, interception, collection, and/or treatment actions designed to prevent entry of pollutants into the nearshore ecosystem.
15	Property Acquisition and Conservation	Transfer of land ownership or development rights to a conservation interest to protect and conserve resources, enable restoration or increase restoration effectiveness.
16	Public Education and Involvement	Activities intended to increase public awareness of nearshore processes and threats, build support for and volunteer participation in restoration and protection efforts, and promote stewardship and responsible use of nearshore resources.
17	Revegetation	Site preparation, planting, and maintenance to manipulate soils and vascular plant populations to supplement the natural development of native vegetation.
18	Species Habitat Enhancement	Installation or creation of habitat features (sometimes specific structures) for the benefit of native species in the nearshore.
19	Reintroduction of Native Animals	Reestablishment of native animal species at a site where they existed or as replacement for lost habitat elsewhere.
20	Substrate Modification	The placement of materials to facilitate establishment of desired habitat features and improve ecosystem functions, structures, or processes.
21	Topography Restoration	Dredging, excavation, and/or filling to remove or add layers of surface material so that beaches, banks, tidal wetlands, or mudflats can be created.

NOTES: Management measures are listed in alphabetical order. No hierarchy or priority order should be inferred. See individual management measure chapters within the document for complete definitions.

SOURCE: Clancy et al. 2009

The guidance document links management measures and associated performance measures to each other, suggesting likely pairings and outcomes, grouping measures by the geomorphic landforms in which they are most likely to be effective, and exploring the anticipated impacts of climate change on nearshore ecological processes. Tacoma could use these tools to develop location-specific guidance related to shoreline armoring and ecological restoration projects based on underlying geomorphology. When combined with decision trees as seen in the WDFW guidance or Seattle's Green Shorelines program, these tools could form the basis of a set of regulations for shoreline development with an eye to climate resilience and ecological function.

3.2.4 Lessons Learned for Tacoma

3.2.4.1 Sea Level Rise

Integrating sea level rise projections into SMPs has presented a challenge for many shoreline jurisdictions in Washington to date. Limited guidance for voluntary adoption of sea level rise regulations currently exists and jurisdictions have noted a number of challenges that complicate the adoption of new regulations related to sea level rise. However, House Bill 1181's directive for WSDOE to update SMP guidance to include sea level rise should address many of the challenges associated with uncertainty around appropriate language. The City of Tacoma may want to consider participating in the development of guidelines as part of the city's SMP update.

3.2.4.2 Soft shorelines

The decision trees in Figures 1 and 2 represent the best tools found to visualize and prioritize the roles of different shoreline stabilization techniques in different areas. Each of these decision trees note allowances for hard armoring in certain cases. Given the city's ongoing sea level rise adaptation project, these decision trees could be modified for use in prioritizing different approaches that are suitable to specific shoreline segments and their geomorphological characteristics. For example, Whatcom County includes an explicit desired hierarchy of shoreline stabilization techniques within their SMP, listing them as follows:

1. No action to allow the shoreline to retreat naturally, and building setbacks and/or relocation;

2. Soft shore defenses (e.g., bioengineering, beach nourishment, protective berms, or vegetative stabilization)

3. Hard armoring only in cases "where it is necessary to retain the use of a site but requires consideration of the full suite of alternative actions before arriving at such a determination."

A series of supportive documents (Johannessen et al. 2014; Clancy et al. 2009) identify which shoreline management practices may be appropriate for an individual site and stress both the importance of site-specific design and the reality that in some cases hard armoring may be essential to protect a structure, at least in the near term. Minimal code language was found requiring certain techniques or strategies.

3.3 Port City Case Studies and Examples

This section includes background research and summaries of climate adaptation policies and projects that have been planned for and/or implemented in port cities, including those in Bellingham, Vancouver (BC), San Diego, San Francisco, Miami, and New York.

3.3.1 Bellingham

The City of Bellingham uses its SMP (City of Bellingham 2023) to regulate development along its shorelines. The SMP was updated in 2013 and the 2021 update is underway. The 2013 SMP does not include regulatory or policy language specific to strategies related to climate change. The update will include a sea level rise vulnerability assessment framework (Romanenko 2021).

The City of Bellingham and Coastal Geologic Services developed a prioritization tool to identify protection and restoration strategies and priority actions within in the WRIA 1 estuarine and marine nearshore environment (City of Bellingham n.d.-a). The tool resulted in the identification of top- and high-ranking restoration and enhancement priorities. For the City of Bellingham, the following priorities were identified (MacLennan et al. 2013):

- 3-year restoration priority:
    - Modify existing structure under railroad crossing to open up tide channel and remove toppled revetment rock from intertidal at Post Point Lagoon shore, up-drift of surf smelt spawning.
- 3-year enhancement priorities:
    - Remove debris and regrade to create intertidal and possibly salt marsh with eelgrass habitats at the Cornwall Avenue Landfill.
    - Remove fill and debris and modify elevations to provide estuarine and riparian vegetation, mudflat, and marsh along the east shore of Padden Creek.

The WRIA 1 prioritization identified coarse-scale priorities then added specificity through a fine-scale analysis. The coarse-scale assessment evaluated the presence of or proximity to important ecological communities (e.g., forage fish spawning and eelgrass) relevant to juvenile salmonids as well as the level of degradation of the shoreline from human modifications. The fine-scale assessment identified specific opportunities to protect, restore, or enhance habitats. These two steps led to a portfolio of prioritized actions to improve marine nearshore conditions.

The City has made investments in the shoreline via projects such as:

- City of Bellingham Boulevard Park Shoreline Improvements – In 2013, Bellingham Parks and Recreation made improvements at Boulevard Park including removing concrete rubble along the shoreline, creating sand and gravel beaches and rock revetments. Portions of the existing lawn were converted to a gravel and sand beach (City of Bellingham n.d.-b).
- Boulevard Park Shoreline and Public Access Enhancement – The project includes rebuilding and enhancing two beaches in the park. The project focuses on beach nourishment, increasing dry beach backshore area, removal of riprap in the intertidal zone, and removal of failing rock revetments. The eastern beach will have a new rock revetment installed further inland. As a result, an eroding trail will be moved further inland, and utilities and a storm drain trench will be relocated within the park. The western beach will have a small revetment and rockery installed and invasive blackberry bushes removed (City of Bellingham n.d.-c).

- Little Squalicum Estuary Project – The project will restore 4.85 total acres of coastal habitat including a 2.4-acre estuary and will remove a fish passage barrier at the mouth of Little Squalicum Creek just two miles east of the Nooksack River Delta (City of Bellingham n.d.-d).
- Post Point Lagoon – Post Point Lagoon is one of seven pocket estuaries in Bellingham Bay. Restoration work in 2008 included "placing large woody debris within and around the lagoon; removing fill from the shoreline, increasing shoreline length by 18% and saltmarsh area by 70%; re-establishing a native marine riparian buffer along the shoreline; protecting native vegetation and habitat elements by restricting access to sections of the upland, shoreline and intertidal zones; and installing educational signs" (City of Bellingham n.d.-e).

3.3.2 Vancouver, British Columbia, Canada

The City of Vancouver, British Columbia, has undergone many different planning initiatives related to climate change, including the 2012 Climate Change Adaptation Strategy, which was updated in 2018 (City of Vancouver 2019), and the Coastal Flood Risk Assessment Program (CFRA) (City of Vancouver 2018), a multi-phase process to determine the risk, consequences, and vulnerability of Vancouver to future sea level rise and storm surge scenarios, including the following recommendations in the third and final phase of the CFRA:

- By-laws, regulations, and policies be developed to guide the design of coastal flood protection infrastructure, to ensure that it is meets a consistent performance standard and is adaptable over time
- City launch a sea level rise design challenge to advance solutions for the most flood-vulnerable areas

In 2018, the City published the Fraser River Foreshore Coastal Adaptation Plan (CAP) (City of Vancouver 2018-a). The CAP is a multi-year undertaking to determine the risk, consequences, vulnerability, and adaptation opportunities of Vancouver to future sea level rise. Included were design attributes to be employed across adaptation approaches, particularly to design with and for nature:

- Restore, rehabilitate or create new foreshore habitat areas where practical
- Address overland flooding hazards by prioritizing green infrastructure solutions for stormwater retention, detention, and infiltration.
- Where feasible allow for river channel migration or expansion to accommodate additional flows (riverine, freshet flooding hazard)
- Work with the natural water dynamics
- Utilize Green Shores techniques for resist approaches
- Flood wall with habitat features
- River channel migration
- Expanded riparian areas
- Remove seawalls and barriers and restore foreshore habitat

The 2022 Vancouver Plan (City of Vancouver 2022), the long-range land use plan to guide growth and change over next 30 years, includes the following direction and policies related to climate change adaptation:

- Direction 3.3 Climate Change Adaptation
    - Policy 3.3.1 Advance natural climate solutions that buffer impacts of climate change, sequester carbon (capture, secure and store carbon from the atmosphere), and improve biodiversity.
- Direction 10.2: Manage Water on Boulevards, Sidewalks, and Streets
    - Policy 10.2.1 Reallocate parts of the public right-of way (e.g., streets and sidewalk areas) to expand the breadth and scale of nature based assets such as green rainwater infrastructure.
    - Policy 10.2.2 Develop a city-wide blue green network of connected park-like streets that manage rainwater, support climate adaptation and biodiversity, and create public space opportunities.
    - Policy 10.2.3 Restore, maintain, and maximize the use of existing natural creeks, streams, and drainage assets.

The City led a collaborative design challenge to rethink the future of the False Creek shoreline called Sea2City Design Challenge (City of Vancouver 2022-a). The project brought together two multi-disciplinary design teams, City staff, local coastal adaptation experts and First Nation representatives, knowledge keepers, and designers from Musqueam, Squamish, and Tsleil-Waututh over a 12-month period to reimagine key sites along Vancouver's False Creek shoreline. One early recommendation from the Sea2City Design Challenge is for Vancouver to change the language of coastal planning to reflect the gradual transition to the softer, more interconnected shorelines the vision speaks to. Outcomes of the Sea2City Design Challenge include the following concepts and pilot projects:

- Re-wilding False Creek
    - The designs incorporate the natural topography of the sites and imagines a future where flood new development sits higher and closer to the boundary of the floodplain. This approach helps restore the natural shoreline to buffer new development while helping improve False Creek water quality and rainwater management. The team imagines a shoreline that creates room for False Creek to safely host more common coastal flood events in the future and expand public access to the shoreline.
- South Shore Pilot Projects
    - In Olympic Village, a forested berm tests how tree and plant species will adapt to changing temperatures, including red cedars, yellow cedars, and sequoias. The berm also serves to raise the elevation at the site and acts as an anchor for the gradual transition of the area.
    - In Stamps Landing, a habitat bench will provide an oasis for people and nature in Leg-in-Boot Square. The habitat bench will demonstrate a soft shores approach to temporary flood protection in an urban setting in the near-term. As sea levels rise, the habitat bench will decay and evolve from an upland, to intertidal, to subtidal feature.

SOURCE: City of Vancouver 2022-a

Figure 3
Stamps Landing Habitat Bench Design

- In terms of adaptive design, the North Shore team recognized that there is uncertainty around the impacts and timing of climate change, and that part of planning for adaptation is to remain open and flexible to timelines that can change significantly as new information is included. Adapting according to shoreline zones that follow the gradient of the shoreline and focusing development above a flood construction level (FCL) of 5.6m is a major consideration for the north shoreline.

The City's Northeast False Creek Plan (NEFC Plan) (City of Vancouver 2018-b) sets the long-term vision for the last remaining piece of large undeveloped land in the downtown along False Creek, and includes the following policies for climate change adaptation and flood protections:

- 11.2.2 Ensure all elements of Northeast False Creek are designed with the latest sea level rise projections in mind. A continuous line of flood protection built to the City's Building By-law

requirements and in accordance with direction from City staff will extend across the site, designed such that it could be raised an additional meter in the future.
- 11.2.3 Any flood management infrastructure put in place to serve as flood defense (e.g., seawall) will be built to the appropriate structural standards to meet Provincial requirements.
- 11.2.4 Design the flood management infrastructure to enhance the public realm, to be a great place for people to walk and bike and to improve the shoreline habitats by incorporating a naturalized approach, supporting the biodiversity and habitat policies of the plan.
- 11.2.5 Ensure no residential levels or critical infrastructure will be placed below the Flood Construction Level. Buildings in the designated floodplain are encouraged to consider additional flood defense design approaches to ensure resilience through the life of the building.
- 11.2.6 Provide a generous tree canopy where possible within Northeast False Creek. A diversity of tree species is encouraged for resiliency.
- 11.2.7 Landscapes should be designed to be drought tolerant and resilient to climate variability. Irrigation needs should be minimized or eliminated.

The City has made some direct investments in climate change adaptation. The Still Creek Enhancement project aims to rehabilitate and enhance Still Creek to create a more naturalized creek corridor, including 10- and 50-year actions for creek enhancement with acquisition of land. Implementing actions will maintain the natural drainage asset, reduce flood risk, and increase biodiversity, aquatic habitat health and sequestration (Still Creek Enhancement 2023).

The City is undergoing a Climate Emergency Action Plan 2020-2025 (City of Vancouver 2020) that includes six large-scale actions (referred to as Big Moves) for Vancouver to reduce carbon pollution by 50%. Big Move 6: Natural Climate Solutions focuses on restored forests and coasts (City of Vancouver 2021). Recently, construction has begun on the Tatlow and Volunteer Park stream restoration project in support of Big Move 6 (Vancouver Board of Parks and Recreation 2020). The Vancouver Park Board is restoring a small segment of a historical stream in Volunteer and Tatlow parks originally known as 'First Creek.' The project's design goals are to improve accessible shoreline access, increase native plantings and biodiversity, create habitat for bird and pollinator species, and restore riparian shoreline.

3.3.3 San Diego

The City of San Diego uses the California Coastal Act, passed in 1976 by the State Legislature, to regulate coastal development (California Coastal Commission 2023). The Coastal Act guides land use planning along the coast of California.

Article 8 specifies: "The commission shall take into account the effects of sea level rise in coastal resources planning and management policies and activities in order to identify, assess, and, to the extent feasible, avoid and mitigate the adverse effects of sea level rise."

Article 4 does not explicitly address climate change, but includes policy language about construction that alters natural shoreline processes:

- 30235. Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fishkills should be phased out or upgraded where feasible.

Beyond that, the municipal code does not detail climate change-specific policies or regulations.
The City conducted a Sea Level Rise Vulnerability Assessment in 2019 (City of San Diego 2019) and presented key findings from the assessment of exposure, sensitivity, and adaptive capacity of critical built, natural, and cultural assets to coastal hazards. The results will inform the identification of adaptation measures to protect critical City assets and services. Additionally, this assessment will inform a broader City-wide multi-hazard vulnerability assessment, which includes analysis for vulnerability to additional climate hazards such as precipitation driven flooding, extreme heat, and wildfires. It is anticipated the vulnerability assessment and related mapping would be updated approximately every ten years, or as necessary to address significant changes in climate change hazard projections.

Asset-owning City departments were consulted to identify which built, natural, and cultural assets owned and/or managed by the City could be considered critical. The selection criteria were:

- If the asset/resource (or its function) is necessary for continuity of important City operations;
- If the asset/resource (or its function) is a key driver in the City's economy;
- If loss of the asset/resource would present equity issues;
- If the asset/resource is critical to safeguarding biological diversity and other environmental considerations

The City selected specific scenarios to be considered in the vulnerability assessment based on the best available climate science. The selected scenarios and corresponding sources included best available localized modeling from the Coastal Storm Modeling System (CoSMoS) for coastal erosion in the area, covering shoreline and cliff retreat under a Medium-High Risk Aversion Scenario of sea level rise by 2100 and various options for coastal armoring or retreat.

In 2021, City Council adopted the City's first-ever climate adaptation and resilience plan, Climate Resilient SD Plan (City of San Diego 2021). The plan includes the following policies:

TNE-5: "Manage the coastline as a social, economic, and environmental resource for current and future generations,"

- For city-owned properties and leaseholds, consider rolling easements to establish a development boundary that moves inward as sea level rises along the shoreline. Establish the easements as needed to allow for natural migration of shoreline and avoid shoreline armoring.
- Update the Coastal Erosion Assessment regularly to identify current conditions of coastline bluffs, beaches, access stairs, ramps, outfalls, seawalls or other related infrastructure. The Coastal Erosion Assessment should be updated every five years to evaluate the status of coastline erosion or shoreline change.
- Utilize adaptive pathways for coastline planning. Adaptive pathways are a sequence of adaptation strategies over time that consider uncertainty and future risk. An adaptive pathways approach should include completion of an economic analysis to evaluate efficiency and effectiveness of adaptation strategies over time. Adaptive pathways should consider: a) Prioritization of nature-based solutions and natural shoreline protection methods to protect areas subject to coastal flooding. b) Consideration of resilience or relocation options for areas highly vulnerable to coastal erosion and/or coastal flooding. c) Consideration of less intensive uses for City assets, such as transition from vehicle based facilities to bike based facilities.

Policy TNE-3: “Prioritize the implementation of nature-based climate change solutions wherever feasible”

- Implement nature-based shoreline protection methods to protect areas subject to coastal flooding. Develop a coastal resilience mater plan that would identify locations for implementation of nature-based solutions to mitigate coastal flooding and erosion, improve coastal resiliency, protect habitat, and increase recreational opportunities for residents and visitors. Nature-based shoreline protection could include beach nourishment, living shorelines, dune restoration, native plantings, habitat restoration, waterfront/floodable parks, kelp farms or oyster reefs.

While the City has not yet made many direct investments in adapting shorelines to prepare for climate change, the City is currently working on numerous plans to address this. A Coastal Resilience Master Plan, estimated to be complete in 2025, will identify specific resilience and conservation needs along the coastline and develop a portfolio of nature-based solutions to promote resilience, protect critical coastal habitats, and support coastal access (City of San Diego 2023). The plan will engage the public; analyze 10 sites based on feasibility, risk, and benefits; develop nature-based solutions for six of the most feasible locations; and select a pilot project. An Environmental Impact Report that analyzes the environmental effects of nature-based solutions to address climate change along the coast will also be prepared.

3.3.4 San Francisco

The guiding policy document for the City & County of San Francisco is the General Plan, which includes the Local Coastal Program (LCP) adopted by the City Planning Commission and the Board of Supervisors and certified by the California Coastal Commission on April 26, 1984 (San Francisco Planning 2023). The LCP is a policy and regulatory document required by the California Coastal Act that establishes land use, development, natural resource protection, coastal access, and public recreation policies for San Francisco's Coastal Zone.

The LCP Amendment is an update to the 1986 Western Shoreline Area Plan that will specifically address sea level rise and coastal erosion concerns along the area. The Western Shoreline Area Plan (San Francisco Planning 2023-a) includes objectives, policies, and implementation measures for Ocean Beach and Coastal Hazards such as:

POLICY 12.1

(a) As the shoreline retreats due to erosion and sea level rise, incrementally remove shoreline protection devices, rubble that has fallen onto the beach, roadway surfaces, and concrete barriers south of Sloat Boulevard.

(d) Import sand to restore the beach and construct dunes. Stabilize dunes with vegetation, beach grass straw punch, brushwood fencing, or other non-structural methods.

POLICY 12.2

(e) Adaptation measures that preserve, enhance, or restore the sandy beach, dunes, and natural and scenic resources such as beach nourishment, dune restoration, and managed retreat shall be preferred over new or expanded shoreline protection devices.

POLICY 12.5

Shoreline protection devices shall be avoided and only implemented where less environmentally damaging alternatives are not feasible. Shoreline protection devices such as rock revetments and seawalls shall be permitted only where necessary to protect existing critical infrastructure and existing development from a substantial risk of loss or major damage due to erosion and only where less environmentally damaging alternatives such as beach nourishment, dune restoration and managed retreat are determined to be infeasible. New or expanded shoreline protection

devices should not be permitted solely to protect parking, restrooms, or pedestrian or bicycle facilities.

The City of San Francisco has begun the process of adjusting a variety of policies to address sea level rise. A floodplain management ordinance was adopted in 2008, and the *Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco: Assessing Vulnerability and Risk to Support Adaptation* was issued in 2014. The City of San Francisco has completed other planning efforts related to climate change, including: 2016 Sea Level Rise Action Plan, 2020 Sea Level Rise Vulnerability and Consequences Assessment, and 2020 Hazards and Climate Resilience Plan.

San Francisco Planning completed the Islais Creek Adaptation Strategy, which assessed future climate risks and identified a range of potential adaptation strategies for the Islais Creek shoreline (San Francisco Planning 2021). Where feasible, the strategy suggested nature-based and living shoreline adaptation strategies to provide flood protection while increasing parks and habitat areas, including:

- Removing aging waterfront structures in favor or living shoreline features that restore a natural edge condition and create passive recreation opportunities
- Consider expanding open space in opportunity areas that could be developed as public/private partnership
- Maintain existing wetland areas and consider regrading areas where they could migrate over time
- Introduce green streets and street-level green infrastructure to reduce localized urban flood risk, reduce peak flows, increase biodiversity and enhance neighborhood character

The Islais Creek Adaptation Strategy also developed the following Toolkit Strategies:

Figure 15: Toolkit Strategies

Direct investments and projects are mostly being led by other entities, such as Port of San Francisco, San Francisco Bay Restoration Authority, San Francisco Recreation & Parks, and others.

3.3.5 Miami

Miami's zoning code establishes standards and procedures for new development or redevelopment in the City including Appendix B - Waterfront Design Guidelines (City of Miami n.d.):

- Walkways along a natural shoreline or rip rap shoreline may be set back from the edge of the shoreline and meander within the waterfront setback area.
- Properties with natural shorelines must provide flood protection…via berm, wall, or similar elements to protect rights of way and adjacent properties from flooding. Flood barriers may be setback from the shoreline if the natural area may safely accommodate flooding.

The Miami Forever Climate Ready is a strategy to reduce the increasing risk of flood, flood, heat, and storm impacts over next 40 years (City of Miami 2023-a). The Miami Forever Climate Ready Plan (City of Miami 2022) established Goal 3, "Protect and enhance our waterfront," with the following objectives:

- Objective 3.1: Reduce the severity, duration, and impact of coastal and riverine flooding on shorelines and surrounding communities.
- Objective 3.2: Update and implement waterfront design standards.
- Objective 3.3: Accelerate investment in features along the waterfront.
    - Update city policy to ensure design scopes for city-owned waterfront and drainage projects prioritize and integrate green infrastructure solutions such as living shorelines and bioswales to improve coastal protection, drainage, and water quality, and enhance natural systems.
    - Continue installation of tidal valves at City outfalls to reduce high-tide flooding through storm drains.
    - Implement changes to City seawall standards considering sea level rise projections through 2060 and designing for adaptability over time. Inform and engage key stakeholders prior to introducing the new standards.
    - Develop and build upon landscaping and vegetation standards that require native plantings for city swales and along waterfront areas that are more resilient to salt water, hurricanes, and extreme weather events.

3.3.6 New York, NY

In March 2021, the City Council passed Local Law 41, which involves the development of a new resilience scoring system for public projects. By 2026, all City projects must meet a stringent set of requirements that will certify their preparedness for extreme weather threats (City of New York Mayor's Office of Climate and Environmental Justice 2022). One of the suggested features includes integration with naturally resilient shoreline features.

The New York City Waterfront Revitalization Program (WRP) (City of New York 2016) is the City's principal Coastal Zone Management tool. The WRP establishes the City's policies for development in the Coastal Zone, a geography defined by legislation that includes the floodplain, as well as other areas that have some relationship with the waterfront. City, state, or federal discretionary actions within NYC's Coastal Zone must be reviewed for consistency with the WRP. This includes zoning changes, infrastructure projects, and funding. Revisions to the WRP approved in 2016 require that all projects take sea level rise projections into consideration. Within the plan, the following policies relate to climate change:

- Avoid fragmentation of natural ecological communities and maintain corridors to facilitate the free exchange of biological resources within and among these communities. Protect those sites which have been identified as key to maintaining habitat connections within ecological systems.

- Protect non-invasive plants from excessive loss or disturbance, and encourage greater quantity and diversity of non-invasive plants to the extent practicable. Select plants that are resilient to current and future changes in climate.
- Prevent the net loss of wetlands by: (1) avoiding the draining of, placement of fill in, or excavation of wetlands; (2) minimizing adverse impacts resulting from unavoidable draining, fill, excavation or other activities; or (3) providing mitigation for any adverse impacts which may remain after all appropriate and practicable minimization measures have been taken. These are presented in order of descending preference with (1) being the most effective and preferred option
- Maintain or create resilient vegetative buffers between wetlands and nearby uses to protect the wetland's character, quality, values, and functions. Buffers should be designed and maintained to preserve hydrologic balance within the wetland and between the wetland and surrounding upland area. The adequacy of the buffer width and composition is determined by: (1) the potential for adverse effects associated with the proposed or existing use; (2) the nature and importance of the wetland and its benefits to the ecological complex; (3) the direction and flow of surface water between a use and the wetland; and (4) the necessity to achieve and maintain a high filtration efficiency or surface runoff as determined by vegetative cover type, soil characteristics, and slope of land. In all cases, the buffer must not be less than that required by state law. If site constraints do not allow sufficient buffer width, consider other management measures or design alternatives to preserve or achieve hydrologic balance.

CHAPTER 4
Climate-Informed Review of Comprehensive Plan and SMP Policies

This section reviews existing Comprehensive Plan and SMP policies that are responsive to climate change, identifies potential modifications to those policies to make them more responsive, and additional climate adaptation strategies for consideration.

4.1.1 Environment + Watershed Health

4.1.1.1 GOAL EN–1 Ensure that Tacoma's built and natural environments function in complementary ways and are resilient to climate change and natural hazards.

Policy EN-1.4 Maintain self-sustaining populations of native plants, native resident and migratory fish and wildlife species, including at-risk species and beneficial organisms such as pollinators.

- Can be used as justification for larger-than-minimum buffers to ensure adequate space for species life cycles

Policy EN-1.5 Protect the quantity, quality and function of high value environmental assets identified in the City's natural resource inventories, including: a. Rivers, lakes, streams and associated riparian uplands b. Floodplains c. Riparian corridors d. Wetlands and buffers e. Groundwater f. Trees and urban forests g. Bays, estuaries and marshes h. Shorelines i. Native and other vegetation species and communities that provide habitat value j. Habitat complexes and corridors, rare and declining habitats such as wetlands, native oak and habitats that support special-status or at-risk plant and wildlife species k. Other natural resources as identified.

- Restore floodplains and connectivity to improve the resilience of streams and rivers and reduce flood risk.

- Reconnect floodplains to increase water retention and storage by removing hard armoring (Loos and Shader 2016).

Policy EN–1.9 Develop hazard mitigation plans that reduce exposure of Tacoma citizens to future disasters or hazards (e.g., flooding, earthquakes, winds).

- Could add more specifics related to climate change: sea level rise, extreme heat, drought, etc.

Policy EN–1.17 Assess and periodically review the best available science for managing critical areas and natural resources and utilize the development of plans and regulations while also taking into consideration Tacoma's obligation to meet urban-level densities under the GMA.

- No change.

Policy EN–1.18 Evaluate climate data and consider climate risks in the development of regulations, plans and programs.

- No change.

Policy EN–1.19 Evaluate trends in watershed and environmental health using current and historical data and information to guide improvements in the effectiveness of City plans, regulations and infrastructure investments.

- Could be expanded to include climate projections to evaluate the suitability of current investments and regulatory standards in light of a changing climate.

Policy EN–1.25 Develop management plans for each of the City's watersheds. Evaluate the current conditions of the watersheds in Tacoma and use the findings to inform decisions about future land use, stormwater planning and urban forest and open space management.

- Improve and expand urban forest management to maximize or conserve carbon storage.

4.1.1.2 GOAL EN–2 Protect people, property and the environment in areas of natural hazards.

Policy EN–2.5 Promote soil stability by retaining vegetation in erosion prone areas.

- No change.

Policy EN–2.7 Establish setbacks around the perimeter of site-specific landslide hazard areas to avoid the potential to undermine these areas, cause erosion and sedimentation problems to downstream or downhill land uses and avoid the risk to human life and safety. Establish broader setbacks in areas at risk for mass wasting.

- Review required buffers and setbacks for steep slopes and shorelines vulnerable to erosion exacerbated by climate change, and establish new minimums, if necessary, so that improvements are not required to protect such structures during their expected life.

4.1.1.3 GOAL EN–3 Ensure that all Tacomans have access to clean air and water, can experience nature in their daily lives and benefit from development that is designed to lessen the impacts of natural hazards and environmental contamination and degradation, now and in the future.

Policy EN–3.1 Ensure that the City achieves no-net-loss of ecological functions over time.

- Ensure no net loss of ecosystem composition, structure, and functions, especially in Priority Habitats and Critical Areas, and strive for net ecological gain to enhance climate resilience.

Policy EN–3.5 Discourage development on lands where such development would pose hazards to life, property or infrastructure, or where important ecological functions or environmental quality would be

adversely affected: a. Floodways and 100-year floodplains b. Geologic hazard areas c. Wetlands d. Streams e. Fish and wildlife habitat conservation areas f. Aquifer recharge areas g. Shorelines.

- Consider climate stressors when determining allowed activities and uses within wetlands and Fish and Wildlife Habitat Conservation Areas (FWHCAs), and ensure regulations maintain habitat integrity and function.

- Coordinate all programs that can affect fish and wildlife habitat to optimize the ability of local policies, rules, and management activities to protect habitats, and look for gaps or inefficient practices that could impede climate resilience.

- Require open space set-asides (such as parks) for new development.

Policy EN–3.6 Limit impervious surfaces within open Space Corridors, shorelines and designated critical areas to reduce impacts on hydrologic function, air and water quality, habitat connectivity and tree canopy.

- Expand reasoning for impervious surface standard for public and private development/redevelopment

- Identify opportunities to expand habitat protection and improve habitat quality and connectivity to foster climate resilience using conservation area designations, buffers, and open space corridors.

Policy EN–3.19 Protect and retain wetlands, rivers, streams and lakes through use of best management practices, managing and treating stormwater runoff, protecting adjacent native vegetation, removing invasive plant species and limiting the use of fertilizers/pesticides or other chemicals.

- Protect and restore wetlands and corridors between wetlands to provide biological and hydrological connectivity that fosters resilience to climate impacts.

4.1.1.4 GOAL EN–4 Achieve the greatest possible gain in environmental health City-wide over the next 25 years through proactive planning, investment and stewardship.

Policy EN–4.2 Encourage landscaping designed to complement local wildlife and native or climate adapted vegetation and help offset the loss of wildlife habitat areas resulting from past development practices.

- Could prioritize native and/or climate-resilient landscaping (e.g., drought tolerance, pest tolerance, etc.)

Policy EN–4.6 Enhance native vegetation along wetlands, rivers, streams and lakes. The City may require new planting of native vegetation and/or removal of non-native species to restore ecological functions of riparian buffers where such activities will enhance the corridor's function.

- Protect and restore riparian vegetation to reduce erosion, provide shade, and support other functions that improve the resilience of streams to climate change.

- Choose native drought- and pest-resistant trees, shrubs, and grasses in restoration efforts to support climate resilience.

- Restore and maintain critical areas and open space areas to maximize the climate resilience benefits they provide.

Policy EN–4.14 Ensure that plans and investments are consistent with and advance efforts to improve the diversity, quantity and quality, of fish and wildlife habitat and Open Space Corridors, especially rare and declining habitat types and habitats that support at-risk plant and animal species and communities.

- No change.

Policy EN–4.15 Ensure that plans and investments are consistent with and advance efforts to prevent the spread of invasive plants, and support efforts to reduce the impacts of invasive animals and insects.

- Could include potential range expansion of non-native and invasive species with climate change

Policy EN–4.21 Reconnect shorelines and upland areas and water courses through habitat conservation and restoration efforts, property acquisition and/or easements.

- Could emphasize sea level rise connection to easing the transition between coastal and inland/upland areas

Policy EN–4.26 Utilize the City's TDR Program to conserve valuable city and regional assets, and continue to develop and enhance the program. Lands meeting the City's criteria for conservation that are located within the designated Open Space Corridors, and lands achieving other open space goals of this Plan, are appropriate "sending areas" for the transfer of development rights to other locations in the City, county and region.

- Could be expanded to explicitly include critical areas

4.1.1.5 GOAL EN–5 Plan at a watershed scale to restore and protect natural resources that contribute to watershed health.

Policy EN–5.2 Improve protections to watershed processes by tailoring zoning and subdivision regulations, sensitive area protections, clearing and grading limitations and stormwater mitigation requirements that are appropriate for each watershed based on the findings of the watershed based analysis, the community's vision for population and job growth and the requirements of the Growth Management Act.

- Connect to climate change adaptation planning in Pierce County and adjacent cities

4.1.2 Design + Development

4.1.2.1 GOAL DD–5 Ensure long-term resilience in the design of buildings, streets and open spaces, including the ability to adjust

to changing demographics, climate, and economy, and withstand and recover from natural disasters.

Policy DD–5.9 Integrate natural and green infrastructure, such as street trees, native landscaping, green spaces, green roofs, gardens, and vegetated stormwater management systems, into centers and corridors.

- Connect to potential impervious surface standard and importance for promoting flood attenuation and groundwater recharge

4.1.2.2 GOAL DD–7 Support sustainable and resource efficient development and redevelopment.

Policy DD–7.5 Encourage site and building designs that make efficient use of water and manage stormwater as a resource.

- Connect to potential impervious surface standard and importance for promoting flood attenuation and groundwater recharge

4.1.2.3 GOAL DD–11 Protect people, property and the environment from environmental hazards.

Policy DD–11.1 Evaluate slope and soil characteristics, including liquefaction potential, landslide hazards, and other geologic hazards.

- Expand to include sea level rise and flooding

Policy DD–11.2 Limit development in or near areas prone to natural hazards where practicable, using the most current hazard and climate change-related information and maps.

- No change

Policy DD–11.3 Encourage development approaches that will enhance the ability of people, wildlife, natural systems, and property to withstand and recover from a natural disaster or other major disturbance.

- Explicitly mention climate change and/or climate-exacerbated hazards

4.1.2.4 GOAL DD–12 Integrate and harmonize development with the natural environment.

Policy DD–12.1 Ensure that new building and site development practices promote environmental health and ecosystem services, such as pollutant reduction, carbon sequestration, air cooling, water filtration, or reduction of stormwater runoff.

- Connect to services provided by critical areas

Policy DD–12.2 Encourage flexibility in the division of land, the siting and design of buildings, and other improvements to reduce the impact of development on environmentally sensitive areas, maintain natural landforms, retain native vegetation, protect specimen trees, and preserve open space.

- Expand to include explicit mention of soft shore stabilization techniques

- Incorporate sea-level rise information, along with tsunami hazard mapping, into critical area delineation for siting critical infrastructure, land-use planning, and emergency management.

4.1.3 Public Facilities + Services

4.1.3.1 GOAL PFS–1 Provide public facilities and services necessary to support existing and new development envisioned in the Urban Form Element.

Policy PFS–1.3 Coordinate and cooperate with federal, state, regional, and local jurisdictions, private industry, businesses, and citizens in the planning, siting, design, and development of facilities serving and affecting the community.

- Connect to importance of creating standards and projects that cross jurisdictional boundaries related to habitat connectivity and corridors, groundwater recharge, flood control, and other projects related to ecosystem services

4.1.3.2 GOAL PFS–4 Provide public facilities that address past deficiencies, particularly those in underserved areas, meet the needs of growth, and enhance the quality of life through acceptable levels of service and priorities.

Policy PFS–4.3 Use the following levels of service to assist in determining the need for public facilities, and as a management tool for monitoring the sufficiency of the facilities:

- Modify habitat/open space standards to explicitly support increased/enhanced buffer standards

4.1.3.3 GOAL PFS–7 Design, locate and provide public facilities with features and characteristics that support the environment, energy efficiency, aesthetics, technological innovation, cost-effectiveness, livability, sustainability, and equity.

Policy PFS–7.1 Design natural infrastructure into projects whenever feasible to mimic ecological processes and minimize the need for built infrastructure.

- Emphasize importance of soft/natural infrastructure in climate adaptation

Policy PFS–7.10 Promote water reuse and water conservation opportunities that diminish impacts on water, wastewater, and surface water systems.

- Connect to groundwater recharge

4.1.4 Shoreline Master Program

4.1.4.1 GOAL 1: To preserve and develop shorelines in a manner that allows for an orderly balance of uses.

*Policy 5***.** Balance the location, design, and management of shoreline uses throughout the city to prevent a net loss of shoreline ecological functions and processes over time.

- Prevention of net loss will require allowing for inland migration of shoreline habitats as sea levels rise, a potential challenge on some sites that may require the development of new area for shoreline function as sites are lost.

Policy 6. Encourage shoreline uses and development that enhance shoreline ecological functions and/or processes or employ innovative features that further the purposes of this Program.

- No change, soft shore armor designs may be considered under this policy.

4.1.4.2 GOAL 3: To conserve shoreline resources and important shoreline features, and protect shoreline ecological functions and the processes that sustain them to the maximum extent practicable.

Policy 3. Acquire or otherwise protect a maximum amount of prime habitat for conservation purposes.

- Could be expanded to specifically include inland acquisitions to accommodate migrating habitats.

4.1.4.3 GOAL 4: To re-establish, rehabilitate and/or otherwise improve impaired shoreline ecological functions and/or processes through voluntary and incentive-based public and private programs and actions that are consistent with the Shoreline Master Program Restoration Plan and other approved restoration plans.

Policy 2. Over time the City will strive to reduce the total amount of shoreline armoring and restore natural shoreline functions.

- Supports the development of regulations that restrict or disallow hard shoreline armoring.

Policy 5. Encourage and facilitate voluntary, cooperative restoration and enhancement programs between local, state, and federal public agencies, tribes, non-profit organizations, and landowners to address shorelines with impaired ecological functions and/or processes.

- This policy could be expanded to include the address of habitat migration needs through barrier removal and land acquisition/conservation.

4.1.4.4 GOAL 6: Protect and enhance shoreline features of archaeological, historic, and cultural value or significance and to preserve these features for the public benefit through

coordination and consultation with the appropriate local, state and federal authorities, including affected Indian tribes.

Policy 3. Collaborate on cultural resource management issues with the appropriate tribal, state, federal and local governments and entities.

- Access to harvest sites along shorelines will be impacted with SLR, as will the prevalence of culturally relevant species.

4.2 Additional climate mitigation and adaptation strategies related to critical areas

The following potential mitigation and adaptation strategies are sourced from the Washington Department of Commerce Model Climate Element Menu of Measures:

- Protect, enhance, and restore ecosystems in order to meet tribal treaty rights and conserve culturally important consumptive and non-consumptive resources including foods, medicinal plants, and materials that could be adversely impacted by climate change.
- Establish or work with partners to establish a native plant nursery and seed bank to support long-term restoration and carbon sequestration efforts.
- Implement actions identified in restoration and salmon recovery plans to improve climate resilience of streams and watersheds.
- Increase the climate resilience of native fish species and aquatic ecosystems by reducing the threat of aquatic invasive species (e.g., fish, plants, invertebrates, etc.).
- Take early action to eliminate or control non-native invasive insect species that take advantage of climate change, especially where invasives threaten native species or ecosystem function.
- Use an integrated approach to prevent the spread and establishment of invasive plant species and enhance the climate resilience of native plant communities.
- Take inventory of and protect climate refugia and habitat connectivity needs for species under stress from climate change.
- Identify, protect and restore submerged aquatic vegetation (eelgrass, kelp, etc.) that provide aquatic habitat, "blue" carbon storage, and other ecosystem services.
- Ensure no net loss of ecosystem composition, structure, and functions, especially in Priority Habitats and Critical Areas, and strive for net ecological gain to enhance climate resilience.
- Restore and maintain critical areas and open space areas to maximize the climate resilience benefits they provide.

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