

Sea Level Rise Impacts on King County Assets



Image: King Tides, Alki, Seattle, December 2019

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

CIP	Capital Improvement Program
County	King County
CoSMoS	United States Geological Survey's Coastal Storm Modeling System
COVID	Coronavirus Disease-19
CSO	combined sewer overflow
DES	King County Department of Executive Services
DLS	King County Department of Local Services
DNRP	King County Department of Natural Resources and Parks
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FMD	King County Facilities Management Division
GIS	geographic information system
KCGIS	King County GIS Center
KCIA	King County International Airport/Boeing Field
Metro	King County Metro Transit Department
mgd	million gallons a day
MHHW	Mean Higher High Water
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
Parks	King County Parks Division
PIN	Parcel Identification Number
Prep.	preparedness actions
PS	pump station
RCP	representative concentration pathway
RES	DES-FMD Real Estate Services
Roads	King County DLS Roads Services Division
RS	regulator station
SCAP	Strategic Climate Action Plan
SLR	sea level rise
SWDM	Surface Water Design Manual
SWSS	King County DNRP WLRD Stormwater Services Section
WA Ecology	Washington Department of Ecology
WCRP	Washington Coastal Resilience Project
WLRD	King County DNRP Water and Land Resources Division
WSDOT	Washington State Department of Transportation
WTD	King County DNRP Wastewater Treatment Division
WWTP	Wastewater Treatment Plant
WWTS	wet weather treatment station

EXECUTIVE SUMMARY

As part of King County's [2015 Strategic Climate Action Plan](#) (SCAP), King County committed to reducing the risk of sea level rise on Puget Sound shoreline homes, businesses, and infrastructure. This report summarizes the results of one component of the 2015 SCAP work on sea level rise: assess sea level rise impacts on King County-owned assets and identify potential adaptation actions to address those impacts.

This report is intended to assist agency efforts to plan for sea level rise by identifying those assets that are likely to experience sea level rise sooner based on their proximity to the shoreline (i.e., high exposure assets) and/or assets that may be a higher priority for adaptive action because of other factors (i.e., assets with a high overall impact rating). Results are summarized by agency as well as across agencies.

This assessment does not replace the need for more detailed sea level rise analysis for each agency and asset; more to the point, it informs where additional analysis may be warranted. Periodic review and update is recommended to account for new developments in sea level rise science, changes in infrastructure condition and use, and other factors that may affect assessment findings.

Assessment Participants and Process

The *Sea Level Rise Impacts on King County Assets* project was completed by an interdepartmental team co-led by the Wastewater Treatment Division (WTD) and the Water and Land Resources Division (WLRD). Participating agencies are listed in Figure ES-1. Many of these agencies were participating in a sea level rise planning exercise for the first time, providing a more comprehensive overview of sea level exposure, impacts, and adaptation measures for County assets relative to past work on sea level rise.

The assessment process involved five key tasks: 1) select sea level rise projections for use in the assessment, 2) map the selected sea level rise projections, 3) complete an inventory of King County assets within the identified sea level rise impact zones, 4) identify and qualitatively evaluate potential sea level rise impacts on those assets, and 5) identify potential adaptation strategies for each asset, asset class, or asset system to address identified impacts. The project covered the King County shoreline, inclusive of Vashon and Maury Islands, and the lower Duwamish River. The lower Duwamish River is considered salt water influenced up to approximately river mile 8, though tidal influence extends further upstream (at least river mile 16.7) depending on time of year and amount of flow (Conn et al 2015).

The assessment utilized recently updated sea level rise projections developed by the Washington Coastal Resilience Project (WCRP) for 171 locations in Washington state (Miller et al. 2018). The specific values selected for the assessment were 2.3 feet and 5.1 feet of sea level rise by 2100, relative to average sea level for 1991-2009. These values are currently considered the 50% and 1% probability of exceedance values, respectively, for 2100, meaning there is a 50% probability that sea level rise will be

Figure ES-1



greater than 2.3 feet in 2100 and a 1% probability that sea level rise will be greater than 5.1 feet in 2100. The year 2100 was selected as the end point for the assessment given the long-lived nature of many King County assets.

		9'-12'	12'-15'	15'-18'
		High Exposure Zone	Medium Exposure Zone	Low Exposure Zone
W a t e r	S h o r e l i n e	<ul style="list-style-type: none"> • Already at risk of coastal flooding from storm surge • Sea level rise impacts occur sooner relative to other mapped zones. • Permanent inundation and/or damage due to increased wave action, tidal reach, storm surge, erosion, flooding, and corrosion. 	<ul style="list-style-type: none"> • Likely to experience periodic sea level rise impacts initially, followed by more chronic impacts later. • Could experience permanent inundation and/or more damage from combination of SLR and surge. • Increased wave action, tidal reach, storm surge, erosion, flooding, and corrosion. • More likely some new issues for management and operation of these assets. 	<ul style="list-style-type: none"> • Could experience episodic impacts associated with storm surge, including short-term coastal flooding, erosion, and saltwater corrosion. • Relative to other mapped elevation bands, impacts not expected until later in the century and only under a more rapid sea level rise scenario. • More likely that sea level rise is a new issue for management and operation of these assets.

Figure ES-2 Mapped Sea Level Rise Exposure Zones.

Three sea level rise exposure zones—a high, medium, and low exposure zone—were mapped relative to the current Mean Higher High Water (MHHW¹) mark of 9.01 feet for King County. The exposure zones, spanning a total of nine feet in elevation change divided into three-foot increments, account for up to 5 feet of sea level rise (mapped in one foot increments), 3.3 feet of storm surge, and a buffer for Lidar and other data uncertainties (e.g. wave dynamics). The timing and nature of sea level rise impacts will vary by exposure zone over time as sea level rises (Figure ES- 2). *Shoreline armoring, sea walls, or other factors that may limit the ability of rising water levels to reach an asset were not included in the mapping approach.*

An overall sea level rise impact rating for each asset or asset class was determined based on an asset’s exposure to sea level rise, sensitivity to sea level rise impacts, and adaptive capacity (Figure ES- 3). Agency staff rated each factor using a qualitative low/medium/high rating system informed by guidelines provided to the project teams. Staff then determined the final, overall potential impact rating based on the cumulative of the three individual factor ratings, taking into account information gathered through the assessment. As a final step, agency staff identified potential adaptation actions that could

Figure ES-3

Assessment Factors

Exposure: how likely it is that an asset will physically experience sea level rise. Exposure is based on physical proximity to the shoreline and the mapped sea level rise exposure zones.

Sensitivity: the degree to which an asset and the service(s) it provides are affected by sea level rise, assuming no adaptive action is taken. In general, low sensitivity is good.

Adaptive capacity: how easily an asset owner can adapt the asset or service to mitigate sea level rise impacts and maintain primary functions. In general, a high adaptive capacity is good.

¹ Mean Higher High Water (MHHW) is a shoreline datum based on the average of the higher (of two) daily high tides observed over a 19-year period.

be taken to reduce or otherwise prepare for sea level rise impacts.

Summary Findings

Overall, the risk of sea level rise is fairly limited for most King County agencies.

This is true both in terms of the overall number of assets located in the sea level rise exposure zones and the number of assets with a high overall impact rating.

This does not mean that sea level rise can be ignored, however. Sea level rise is expected to affect a variety of existing assets and will need to be factored in the ongoing asset management. It is also critical that sea level rise be factored into siting, design, and operation considerations for new assets.

Sea level rise drives a variety of changes along the marine shoreline that can affect shoreline infrastructure and natural systems. These impacts include permanent inundation of low-lying areas; increased coastal flooding due to higher daily high tides, King Tides, and storm surge events; higher wave energy and/or increased exposure to waves; increased shoreline or bluff erosion; and increased saltwater and/or groundwater intrusion due to a higher groundwater table.

WTD and the Parks Division (Parks) have the most fixed assets within the mapped sea level rise zones, including the most within the high exposure zone (Table ES-1). By virtue of their proximity to the shoreline and lower elevation, these high exposure zone assets will experience sea level rise impacts sooner relative to other mapped assets, barring existing protective features (e.g., a seawall) or adaptive measures that change the exposure or sensitivity rating (e.g., moving or discontinuing use the asset, elevating a structure).

Table ES-1. Assets with a <u>High Exposure Rating</u> . Results are in alphabetical order by Division.			
Asset Class Owner	Asset or Asset Class	Exposure Rating	Overall Impact Rating
Facilities Management Division (FMD/ DES)	“Flour Mill” Properties, Harbor Island, Seattle	MEDIUM / HIGH	MEDIUM
Marine Division (Metro)	Water Taxi Ferry Service (downtown Seattle, West Seattle, Vashon Island)	HIGH	LOW
Parks Division (DNRP)	Dockton Park and Natural Area*, Maury Island	HIGH	HIGH
	Ellis Creek, Forest Glen, and Raabs Lagoon Natural Areas; Vashon Island	HIGH	MEDIUM
	Bluff Back Natural Areas (8 sites), Spring Beach Natural Area and Maury Island Maine Park, Vashon Island	HIGH	LOW
Road Services Division (DLS)	Vashon and Maury Islands connector roads only	HIGH	HIGH
Wastewater Treatment Division (DNRP)	Pump Stations (8 stations)	HIGH	HIGH
	Regulator Stations (10 stations)	HIGH	MEDIUM
	Conveyance Lines	HIGH	MEDIUM

*Dockton Natural Area as a natural area would have a lower overall impact rating. Because Parks manages Dockton Natural Area and Dockton Park as an integrated asset, the overall impact rating for the Park was used for both sites.

Although WTD and Parks have many assets in the high exposure zone, the need to actively prepare those assets for sea level rise is notably different. WTD’s high exposure assets are part of an interconnected network of built assets that would be negatively affected by sea level rise; impacts on one asset could lead to impacts in other parts of the conveyance system, including wastewater treatment. In contrast, with the exception of Dockton Park, Parks shoreline assets are natural areas that can generally serve their intended function even as the sites adapt physically and ecologically to sea level rise. Potential issues that will need to be accounted for at Dockton Park include impacts on built amenities and services, reduced public access, and limits on the ability to relocate infrastructure with higher amounts of sea level rise.

Other assets with high exposure included assets owned by Roads, the Facilities Management Division (FMD), and Metro’s Marine Division. A small portion of Roads’ network on Vashon and Maury Islands is located within the high exposure zone. These assets include portions of arterial connector roads along the shoreline of

Vashon and Maury Islands. The connector roads regularly experience shoreline flooding driven by extreme tides and storm surge, sometimes requiring lane restrictions or road closures. These small road segments will be increasingly affected by sea level rise sooner unless adaptive measures (e.g., raising road elevations, moving roads, or building causeways) become a viable financial option.

FMD’s greatest exposure to sea level rise is via the leased “Flour Mill” Properties on Harbor Island. Leased assets at that site sit in high and moderate exposure zones. The primary sea level rise concern for the Flour Mill properties is loss of lease revenue if the site is rendered less commercially useable due to inundation blocking access or otherwise interrupting use of the site.

Lastly, the Water Taxi passenger ferry terminal docks managed by Metro’s Marine Division are located in the high exposure zone; these facilities must be located on the shoreline due to the nature of the service provided by the Water Taxi. Water Taxi infrastructure is designed to accommodate changing tide levels, creating good adaptive capacity. Sea level rise will be an important consideration for future construction of any supporting fixed assets related to Water Taxi service.

Table ES-1 Assets with a High Overall Impact Rating. Results are in alphabetical order by Division.

Asset Class Owner	Asset or Asset Class	Exposure Rating	Overall Impact Rating
King County International Airport (DES)	North, Central and South Central Basin, Duwamish Valley	LOW / MEDIUM	HIGH
Parks Division (DNRP)	Dockton Park and Natural Area*, Maury Island	HIGH	HIGH
Road Services Division (DLS)	Vashon and Maury Islands connector roads only	HIGH	HIGH
Wastewater Treatment Division (DNRP)	Pump Stations (8 stations)	HIGH	HIGH
	West Point Wastewater Treatment Plant	MEDIUM	HIGH

**Dockton Natural Area as a natural area would have a lower overall impact rating. Because Parks manages Dockton Natural Area and Dockton Park as an integrated asset, the overall impact rating for the Park was used for both sites.*

While the exposure rating is helpful for identifying which assets may need to be adapted to sea level rise sooner, it is also important to prepare those assets with a high overall impact rating regardless of exposure rating. Five assets or asset classes were assessed to have a high overall impact rating (Table ES-2). This included two major assets with limited exposure to sea level rise: the West Point Wastewater Treatment Plant and the King County International Airport. Although the potential for sea level rise to affect both facilities is considered low at this point in time, the complexity of the facilities and the critical nature of the assets warranted assigning those assets a high overall impact. Other factors that may influence when to adapt an asset for sea level rise include the cost and anticipated life span of the preparedness measure(s) being considered, unique “windows of opportunity” for addressing sea level rise (e.g., a planned replacement or retrofit), and equity considerations, for example.

Preparing for Sea Level Rise

King County agencies identified a variety of potential actions for adapting to sea level rise. Actions generally included the following:

- Making structural modifications to existing infrastructure,
- Temporary relocation of services or increased use of other short-term coping strategies,
- Permanent relocation of infrastructure or services,
- Increasing inspection and/or monitoring of conditions,
- Conducting additional studies to address key information gaps,
- Increasing connection and collaboration with local and regional partners on issues related to sea level rise,
- Incorporating sea level rise considerations into decision making processes and capital planning/asset management, and
- Letting natural assets adapt to sea level rise as it occurs.

Determining which adaptive actions to implement will depend on the specific nature of the assets affected, how quickly sea level rises, and the cost of adaptive measures, among other factors. In all cases, it will be important that King County agencies periodically revisit and update the results of this assessment to reflect changes in sea level rise science, operations, facilities, and other factors that may influence exposure and sensitivity to sea level rise. Accounting for sea level rise in the location, design, and operation of existing and future assets near the shoreline will also be critical.

King County’s commitment to preparing for sea level rise also continues in the [2020 SCAP](#). The 2020 SCAP includes multiple actions that will benefit or otherwise help shape King County agency efforts to prepare for sea level rise. This includes incorporating sea level rise into capital planning (Prep. 1.1.1), developing shared climate resources and projections to guide planning (Prep. 2.1.1 and Prep 2.1.2), working with the U.S. Geological Survey to model projected changes in the magnitude, frequency, and timing of coastal flooding along the King County shoreline (Prep 2.2.4), strengthening sea level rise planning partnerships in the lower Duwamish (Prep 4.2.1), and increasing public engagement on Vashon-Maury Island related to sea level rise (Prep 5.1.2). Progress on these actions will be reported biennially in accordance with County requirements for SCAP reporting.

1. INTRODUCTION

King County's [2015 Strategic Climate Action Plan](#) (SCAP) identified a broad range of priority actions for reducing greenhouse gas emissions in King County and preparing for the impacts of climate change. As part of that plan, King County committed to reducing the risks of sea level rise on Puget Sound shoreline homes, businesses, and infrastructure. Work on that effort was led by the Water and Land Resources Division (WLRD) in the Department of Natural Resources and Parks (DNRP).

This report summarizes the results of one component of the 2015 SCAP sea level rise risk reduction effort: assess sea level rise impacts on King County-owned assets and identify potential adaptation actions to address those impacts. The assessment, completed by an interdepartmental team co-led by the Wastewater Treatment Division (WTD) and WLRD, looked to provide a preliminary answer to the following over-arching question:

How does sea level rise affect King County-owned assets and what are the potential adaptation actions that County programs could take to reduce or otherwise adapt to those impacts?

The assessment involved the following steps:

1. Review current science and select appropriate sea level rise projections for which to plan.
2. Map areas that may be affected by the selected sea level rise intervals.
3. Inventory assets owned by King County within the identified sea level rise impact zones.
4. Identify and evaluate sea level rise impacts on assets.
5. Identify potential adaptation strategies for each asset, asset class, or asset system to address identified impacts.

Participating agencies included the Department of Executive Services (Facilities Management Division and King County International Airport), Department of Local Services (Roads Services Division), Metro, and the DNRP (Parks Division, WLRD, and the WTD).

This report is intended to assist County efforts to plan for sea level rise impacts by identifying those assets that are higher adaptation priorities based on an asset's overall impact rating or exposure rating. **This assessment does not replace the need for more detailed analysis for each agency and asset; more to the point, it informs where additional analysis may be warranted.** As expected with changing climate conditions, this assessment will need to be updated periodically to account for updates in sea level rise science and projections, changes in infrastructure and service delivery, and other factors that may affect assessment findings.

2. BACKGROUND

2.1 Sea Level Rise Projections for King County

Sea level rise is a well understood impact of ongoing climate change, driven by a combination of water expansion due to warmer ocean temperatures and increased glacial melt from land-based glaciers and ice sheets (principally Greenland and Antarctica). Local factors, including changes in land elevation, will also influence how much sea level change occurs at a given location.

Sea level rise drives a variety of changes along the marine shoreline that can affect shoreline infrastructure and natural systems. These impacts include permanent inundation of low-lying areas; increased coastal flooding due to higher daily high tides, King Tides, and storm surge events; higher wave energy and/or increased exposure to waves; increased shoreline or bluff erosion; and increased saltwater and/or groundwater intrusion (due to a higher groundwater table).

The *Sea Level Rise Impacts on King County Assets* assessment utilized sea level rise scenarios developed in 2018 as part of the Washington Coastal Resilience Project (WCRP) (Miller et al. 2018). The WCRP combined the latest science on global sea level rise with updated information on rates of vertical land movement in Washington to provide a more detailed understanding of how sea level rise will change along the Washington coastline.² The WCRP also used a new probabilistic approach for developing sea level rise scenarios that assessed the likelihood of reaching or exceeding a specific amount of sea level rise in a given period of time. Probabilistic scenarios are provided through 2150 for two greenhouse gas scenarios: a low greenhouse gas scenario (RCP 4.5) and a high greenhouse gas scenario (RCP 8.5).³

The WCRP produced sea level rise projections for 171 locations along the Washington coastline. Multiple WCRP locations aligned with shoreline areas of interest for the King County assets assessment. Differences between the scenarios for the various locations were minimal, however. As a result, the scenarios centered over the location of National Oceanic and Atmospheric Administration's (NOAA) long-term tide gauge on Coleman Dock in downtown Seattle were used as the basis for selecting and mapping sea level rise values.

Sea level rise projections for Seattle through 2100 for the high greenhouse gas scenario are shown in Figure 1. The high greenhouse gas scenario was selected as a basis for the assessment given greenhouse gas emission trends. The year 2100 was selected as the end point for the assessment given the long-lived nature of many King County assets. It is important to note that the choice of a low versus high greenhouse gas scenario does not have a notable impact on the WCRP projections through mid-century. By 2100, differences between the two scenarios become more pronounced but are still relatively small given the overall magnitude of change, particularly at the higher end of the projections.

The project team limited the amount of sea level rise considered to a maximum of five feet of sea level rise by 2100. This amount is consistent with the 1% probability of exceedance value for 2100 (5.1 feet), meaning there is a 1% probability of sea level rise being higher than 5.1 feet in 2100.

² Differences in the direction and rate of vertical land movement (i.e., differences in the amount of uplift or subsidence occurring along the Washington coast) will affect how much sea level rise occurs at a given location.

³ The Intergovernmental Panel on Climate Change selected four representative concentration pathways (RCPs), which were defined by their total radiative forcing (cumulative measure of human emissions of greenhouse gases from all sources expressed in Watts per square meter) pathway and level by 2100. The RCPs were chosen to represent a broad range of climate outcomes, based on a literature review, and are neither forecasts nor policy recommendations.

The team additionally selected two feet of sea level rise as a lower level threshold. This value is consistent with the 50% probability of exceedance value for 2100. Two feet is also the 1% probability of exceedance value for 2060, allowing County staff to simultaneously identify impacts that could unfold over two different time horizons. While higher (and lower) amounts of sea level rise are possible by 2100 and beyond, the selected limits on amount (two feet and five feet) and timeframe (2060 and 2100) were considered appropriate for identifying higher risk impacts to current and planned King County assets.

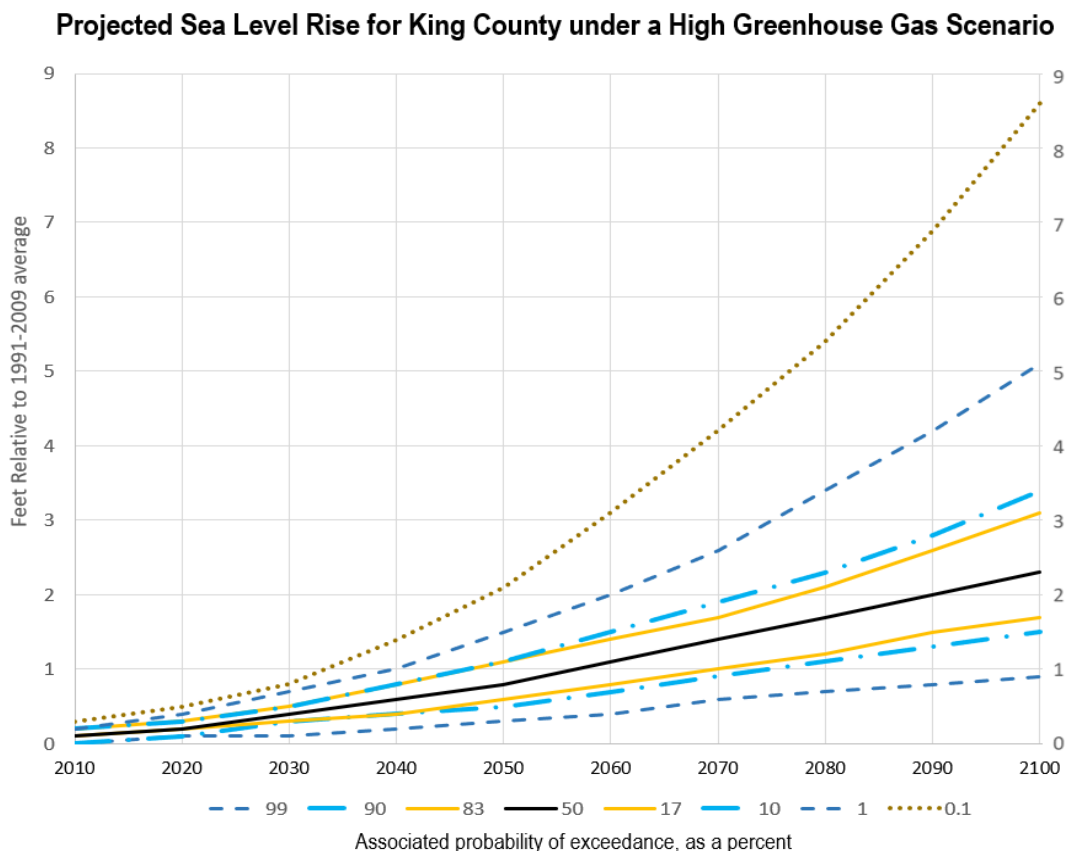


Figure 1. Projected Sea Level Rise in King County, in Feet, through 2100 for a High Greenhouse Gas Scenario. Values included for all probability of exceedance intervals. A 99% probability of exceedance, for example, means that there is a 99% probability that sea level will be higher than the value shown at a given point in time. The 50% and 1% probability of exceedance values for the high greenhouse gas scenario were selected for the King County assets assessment. All values are relative to contemporary sea level, averaged over 1991-2009. All projected values are 19-year average values centered over the year shown (e.g., the projection for 2050 is the average change for 2040-2059). Projections for additional time periods (through 2150), probability of exceedance values, and shoreline areas are available from the WRCF. *From Miller et al. 2018, online data tool.*

2.2 Mapping Sea Level Rise Projections for King County

Sea level rise exposure maps for the King County shoreline, inclusive of Vashon-Maury Island, were developed by WTD for the assessment (Figure 2). The mapping effort also included the lower Duwamish River, which is currently considered salt water influenced up to approximately river mile 8, though tidal influence extends further upstream (at least river mile 16.7) depending on time of year and amount of

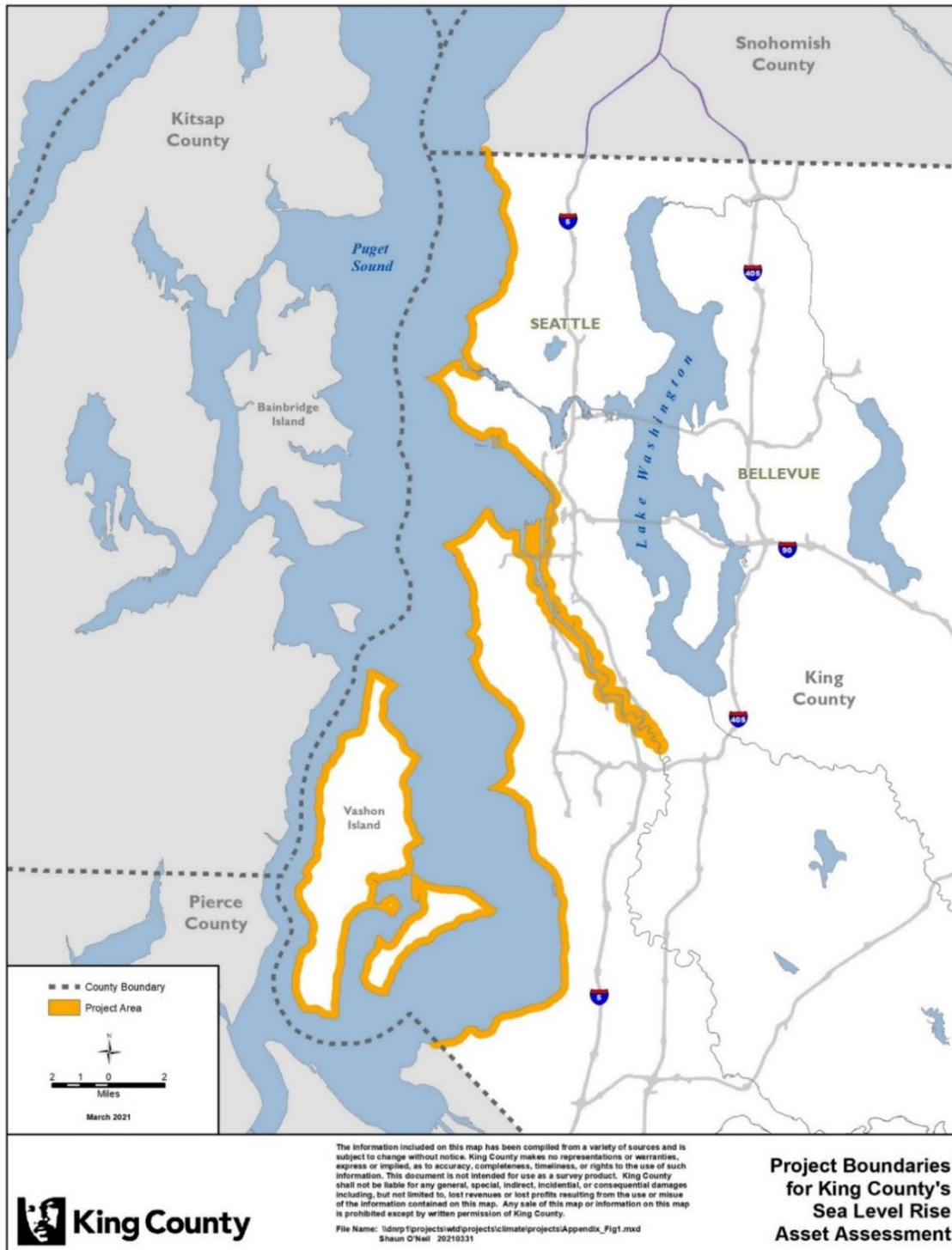


Figure 2. Project Boundaries for King County's Sea Level Rise Asset Assessment. This is not a map of sea level rise. This is a map showing the project area along the Puget Sound coastline. *Image: KCGIS and WTD 2019.*

flow (Conn et al. 2015). Sea level rise is expected to affect daily high tide and storm surge heights in the lower Duwamish. Sea level rise may also exacerbate river flooding in the lower Duwamish and could result in higher groundwater levels. Potential changes in river flooding and groundwater are not included in the sea level rise exposure maps.

Three sea level rise exposure zones—a high, medium, and low exposure zone—were mapped relative to the current Mean Higher High Water (MHHW) mark using Geographic Information System (GIS) mapping. MHHW is a common shoreline datum based on the average of the higher (of two) daily high tides observed over a 19-year period. MHHW was selected as a reference point for determining the extent and impacts of higher daily high tides. The current MHHW elevation in King County is 9.01 feet, as measured at the Coleman dock tide gauge in Elliott Bay/Seattle.

Table 1. Sea Level Rise Exposure Zones.

Exposure Zone	Change from Mean Higher High Water (MHHW)	Elevation in NAVD88
Current	MHHW (<i>current daily high tide</i>)	9 feet
High	MHHW +3 feet (<i>current 1% annual chance coastal flood event</i>)	12 feet
Medium	MHHW +6 feet	15 feet
Low	MHHW +9 feet	18 feet

Notes: NAVD88 - North American Vertical Datum of 1988. MHHW - Mean Higher High Water

A total of nine feet in elevation change, divided into three-foot increments, provided the basis for the sea level rise exposure zones (Table 1). This total included up to 5.1 feet of sea level rise (mapped in one foot increments), 3.3 feet of storm surge,⁴ and a small buffer for documented uncertainties with Lidar elevation mapping near shorelines and other data uncertainties (e.g. wave dynamics).⁵ Shoreline armoring, sea walls, or other factors that may limit the ability of rising water levels to reach an asset were not included in the mapping approach.

It is important to note that in a limited number of locations, the mapping methodology may pick up areas that meet the elevational threshold for different exposure zones but may not be hydraulically connected. A more detailed site assessment is recommended in locations where this may be occurring. These areas were retained in the assessment given the planning focus of the work; it was decided that being more inclusive was better for the purposes of the assessment.

The timing and nature of sea level rise impacts will vary by exposure zone, as described below. These differences are important for understanding how sea level rise can affect an asset and what level of adaptation may be needed at a site.

- The **high exposure zone** (the 9-12 foot NAVD 88 elevation band) is the zone in closest proximity of shoreline. The high exposure zone represents the area already at risk of coastal flooding from storm surge (the current MHHW plus an additional three feet of storm surge). Because of its proximity to the shoreline, the high exposure zone will experience sea level rise impacts sooner

⁴ Storm surge refers to the increase in coastal water level due to the effects of low pressure weather systems and wind events. High tides are often higher than predicted when these conditions occur, contributing to increased coastal flooding, erosion, and other impacts. The historical 1% annual chance coastal storm surge, also known as the 100-year flood elevation, was used to represent future story surge due to uncertainties in how sea level rise will affect storm surge size (Miller et al. 2019).

⁵ See, for example, [Mapping Inundation Uncertainty](#) (NOAA Coastal Services Center 2010)

relative to other mapped exposure zones. Assets located within the high exposure zone are most likely to experience permanent inundation and/or damage (chronic or sudden) as sea level rises due to increased wave action, tidal reach, storm surge, erosion, flooding, and corrosion.

- The **medium exposure zone** (the 12-15 foot NAVD 88 elevation band) represents an additional three feet of elevation over the high exposure zone. Assets located within the medium exposure zone *could* experience permanent inundation and/or more damage (chronic or sudden) from any combination of sea level rise and surge that puts water levels between 12 and 15 feet of elevation. Related impacts include increased wave action, tidal reach, storm surge, erosion, flooding, and corrosion. Assets in this elevation are less likely to have previous experience with these impacts, making it more likely that exposure to saltwater, wave energy, and other impacts are new issues for management and operation of these assets. Relative to other mapped elevation bands, assets in this elevation are likely to experience periodic sea level rise impacts initially, followed by more chronic impacts later.
- The **low exposure zone** (the 15-18 foot NAVD 88 elevation band) represents an additional three feet of elevation over the medium exposure zone. Assets in the low exposure zone could experience episodic impacts associated with storm surge, including short-term coastal flooding, erosion, and saltwater corrosion. Assets in this elevation are least likely to have experience with these impacts, making it more likely that sea level rise is a new issue for management and operation of these assets. Relative to other mapped elevation bands, impacts on assets in this elevation range are not expected until later in the century and only under a more rapid sea level rise scenario.

2.3 Conducting the Assessment

The King County assets assessment drew on staff expertise to provide an initial assessment of sea level rise impacts and potential adaptation strategies. This approach is consistent with rapid vulnerability assessment processes used by other jurisdictions, including the City of Tacoma (Cascadia Consulting Group 2016) and the City of Seattle (GGLO 2017). Key steps in the assessment process are briefly summarized below.

Step 1: Identify assets for the assessment. Participating agencies compiled an inventory of agency assets in each sea level rise exposure zone using GIS. The results were evaluated by each agency and grouped into asset classes, where appropriate, to streamline the impacts assessment process.

Step 2: Conduct a climate impacts assessment. Agency staff conducted a climate impacts assessment for each asset or asset class identified in Step 1 based on the following factors:

- **Exposure:** The exposure assessment identified and rated how likely it is that an asset will physically experience sea level rise. An asset's exposure was determined based on the GIS analysis in Step 1, i.e., by the asset's location relative to the shoreline and the sea level rise exposure zones mapped for this assessment.
- **Sensitivity:** The sensitivity assessment identified and rated the degree to which an asset and the service(s) it provides are affected by sea level rise, assuming no adaptive action is taken. Sensitivity is influenced by a variety of factors, including infrastructure design, age, condition, and criticality. Sensitivity of natural systems is influenced by changes in physical processes as well as impacts on priority species and the compounding effects of non-climate stressors such as pollutant loading and development.

- **Adaptive capacity:** The adaptive capacity assessment identified and rated how easily an asset owner can adapt the asset or service to mitigate sea level rise impacts and maintain primary functions. In general, assets that are likely to require a significant level of effort to reduce sea level rise impacts are going to be more vulnerable to sea level rise (holding all other factors equal) than assets requiring less effort to adjust or adapt. Like sensitivity, adaptive capacity is influenced by a variety of factors, including cost, asset age and design, system interdependencies, and feasibility (political, operational, or otherwise).

Agency staff rated each factor using a qualitative low/medium/high rating system informed by guidelines provided to the project teams. Staff then determined a final, overall potential impact rating based on the cumulative of the three individual factor ratings, taking into account information gathered through the assessment. Summary results for Steps 1 and 2 are provided by agency in Section 3, Asset Assessment and Adaptation Actions.

Step 3: Identify potential adaptation actions. Drawing on information collected from the impacts assessment in Step 2, agency staff identified potential adaptation actions for each asset or asset class that could be taken to reduce or otherwise prepare for sea level rise impacts. Assets that have a high(er) exposure to sea level rise and/or which are likely to experience more significant impacts (relative to other assets) are more likely to be identified as near-term preparedness priorities. Action on assets with medium or low exposure to sea level rise may still be warranted in the near term depending on the impacts being addressed, the criticality of the asset, the cost and anticipated life span of the preparedness measure(s) being considered, unique “windows of opportunity” for addressing sea level rise (e.g., a planned replacement or retrofit), and equity considerations, among other factors. The results of Step 3 are provided by agency in Section 3.

3. ASSET ASSESSMENT AND ADAPTATION ACTIONS

3.1 Department of Executive Services (DES)

3.1.1 Facilities Management Division (FMD)

The King County Facilities Management Division (FMD) oversees and maintains the County's real estate assets and is comprised of four sections:

- **Building Operations** is responsible for services, maintenance, and building operations as well as building security. This group manages over 25 buildings in the county, in the geographic area of downtown Seattle area and the surrounding metropolitan cities. Some examples of these properties are the District Courts, King Street Center, County parking garages and the Communications and Emergency Coordination Center.
- **Major Projects and Capital Planning** is tasked with constructing large-scale projects, such as the King Street Center⁶.
- **Operations and Finance** manages fiscal needs, business planning, performance management, and FMD emergency planning and response.
- **Real Estate Services (RES)** acquires property, negotiates leases, and handles property management. RES provides specialized leasing and support services to King County agencies, such as leasing County-owned land or facilities to other governmental agencies or to private parties.

3.1.1.1 Impacts Assessments: DES-FMD

FMD staff identified several single and grouped assets (Table 2) managed by FMD and located in the mapped sea level rise exposure zones. These are the “Flour Mill” Properties located on Harbor Island, Seattle; Lower Duwamish Triangle Properties located in the lower Duwamish Valley, Seattle; and the King Street Center located in the southern area of downtown Seattle.

Overall, the risk of sea level rise is fairly limited for FMD assets given that most FMD assets were mapped in the **low to medium exposure zones** and all assets had **low or medium overall impact ratings**. Results for the assessment are described in the sections below and summarized in Table 2.

Harbor Island “Flour Mill” Properties

The Harbor Island “Flour Mill” Properties consist of nine contiguous parcels totaling approximately 13.7 acres (Figure 3). The property has vehicular and rail access, including critical use access to a five-track easement abutting the Port of Seattle Terminal 10 at the north margin of the North Yard area. These parcels were purchased by King County Solid Waste Division in 2003 as a potential future transshipment location for solid waste. This majority of the asset is leased to Raymont Industries, an intermodal transshipment logistics company. A warehouse (“E”) is being used to store furniture donated to help re-home

⁶ <https://www.kingcounty.gov/about/contact-us/locations/KingStreet.aspx>

homeless families and coronavirus disease (COVID) storage for tiny houses. In 2021, King County opened a 117,000 sq. ft. sound stage (King County Harbor Island Studios) at the site for TV/movie production. Approximately one-half of this asset sits in the **medium exposure zone** with the other half within the **high exposure zone** (Figure 3; Table 2).

The primary sea level rise concern for the Flour Mill properties is loss of lease revenue if the site is rendered less commercially useable due to inundation blocking access or otherwise interrupting use of the site. If sea level rise impacts were to impair use of the five-track easement for more than 18 months (Figure 3), King County might lose the easement. Any direct damage from inundation and hydraulic impacts from tidal surge are also a concern for onsite property and equipment. Additionally, a nonfunctional and inaccessible backflow valve (“flap gate”) on the discharge pipe from a stormwater treatment facility allows seawater to flow toward the facility during high tides. Sea level rise will exacerbate this situation if not addressed.

Table 2. FMD-Managed Properties Exposure Zone and Overall Impact Ratings Asset Assessment Ratings.

Asset / Asset Class		General Description	Exposure Zone	Overall Impact Rating
“Flour Mill” Properties , Harbor Island, Seattle (PINs 7666703015, -16, -17, -20, -25, -30, -35, -40, -50)		Majority of this asset is currently managed through a five-year lease with Raymont Industries, an intermodal trans-shipment logistics company. Structures include a leased administrative building; storage warehouse “E”, old flour mill with silos, and a new (April 2021) TV/movie production studio.	MEDIUM / HIGH	MEDIUM
Lower Duwamish Triangle Properties , Seattle	Duwamish-Manson Lessees: Manson Construction (Manson) / Cadman-Lehigh (PINs 1924049067, -41, -70, -52)	Manson (marine construction and dredging services) operates and uses storage on the two northernmost parcels. Cadman-Lehigh subleases from Manson the two southern parcels for a ready-mix concrete plant, storage and shipment staging for concrete-making materials, some small structures, and a small fuel tank farm.	LOW / MEDIUM	MEDIUM
	Duwamish - Utilities W. Lessees : United Western / Ardagh Glass (Ardagh) (PIN 1924049051)	A large structure on the northern portion is occupied by United Western (a foundry and abrasive products supplier). Ardagh leases the remainder of the parcel for recycled glass storage.	LOW / MEDIUM	MEDIUM
	Duwamish-Ball-Incon Lessees : Ardagh (PIN 1924049002) and J.A. Jacks (PIN 192049043)	J.A. Jacks subleases the northern parcel from Ardagh for construction materials storage and transshipment. Parcel has a building and exposed piles of materials. Ardagh leases, occupies, and partially subleases a large warehouse on the southern parcel for a variety of industrial and warehouse uses including glass recycling.	LOW/ MEDIUM	MEDIUM
King Street Center , Seattle (PIN 5247800795)		Eight-floor office building with parking garage occupied by multiple County agencies. The lowest floor is approximately one full story below street grade.	LOW	LOW

Notes:

PIN= Parcel Identification Number

Exposure zone and overall impact rating options are high, medium, or low. A high impact rating means the asset is expected to be affected by sea level rise in ways that significantly impact use of the asset.

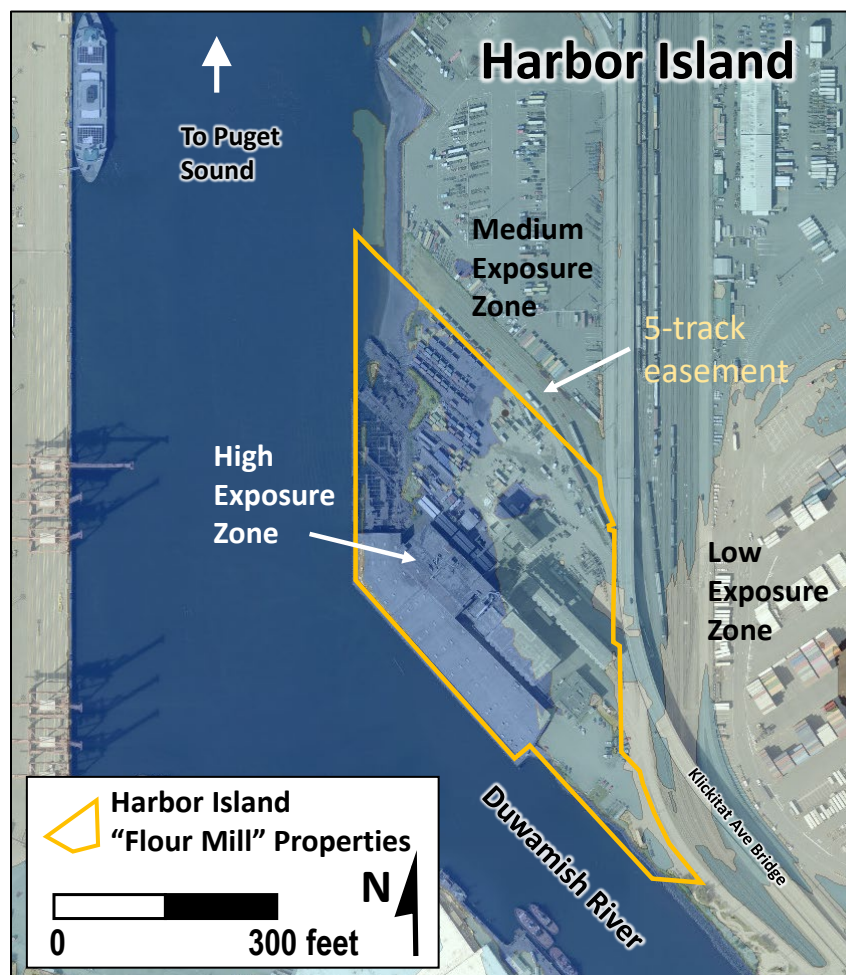


Figure 3. Harbor Island “Flour Mill” Properties and Sea Level Rise Exposure Zones. Nine contiguous parcels (PINs 7666703015, -16, -17, -20, -25, -30, -35, -40, and -50) leased by Raymont Industries, an intermodal trans-shipment logistics company. The asset is mapped within the medium exposure zone with about one-third of the asset within the high exposure zone. The properties have rail access to the 5-track easement to the north of the northernmost yard. Image: SLR and KCGIS (2018-2020).

An additional sea level rise concern is the potential that some onsite materials could be mobilized during flooding events, potentially impacting nearby parcels and presenting environmental hazards if allowed to enter the Duwamish River. Under some circumstances (e.g. lease ends, lessee bankrupts), the County could be liable for cleanup costs and/or penalties.

While there are legal strategies that could strengthen the County’s current indemnification language, the site and access to it would be difficult to protect physically from tidal surge or complete inundation. Additionally, the nature of operations at the site are sensitive to disruption and the economic loss to the County and the lessee could be significant if the site were rendered useless due to sea level rise. Potential adaptive actions ranging from reducing the lease rate to selling the property are available to the County, however. Given these options, the asset was assigned a **medium impact rating**.

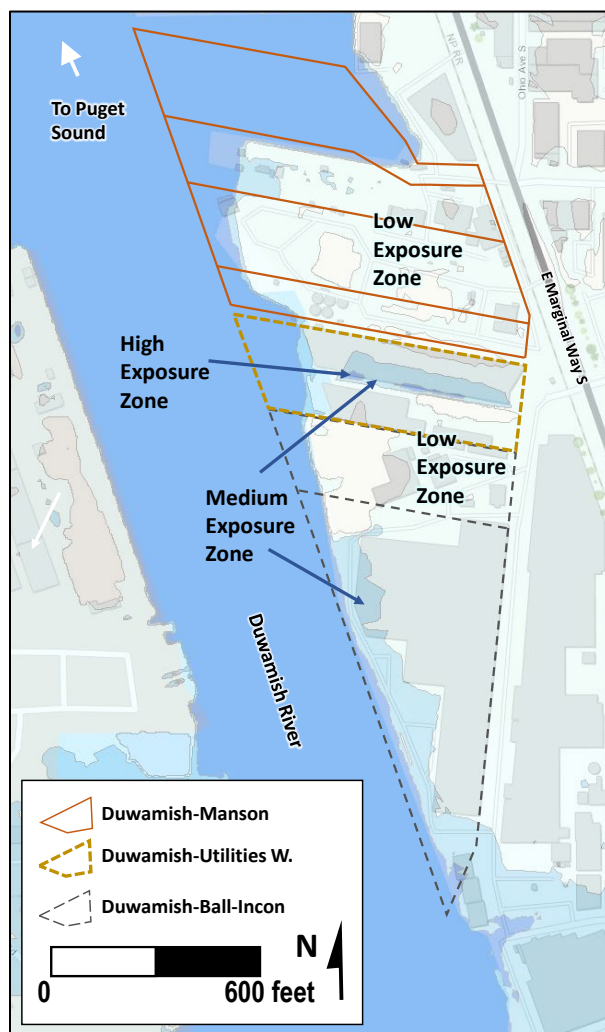


Figure 4. Triangle properties and Sea Level Rise Exposure Zones. Manson leases the four northernmost parcels. United Western & Ardagh occupy the middle parcel, and Ardagh & J.A. Jacks occupy the southernmost two parcels. The majority of the parcels are mapped within the low exposure zone with some mapped in the medium exposure zone in the southwestern parcel. The high exposure zone mapped area above is likely an elevational mapping artifact. Image: SLR and KCGIS (2018-2020).

Lower Duwamish Triangle Properties

The Lower Duwamish Triangle Properties are 27.8 acres of contiguous parcels along the Duwamish River in Seattle, WA (Figure 4). These parcels were purchased with Harbor Bond revenues early in the last century and managed as a revenue source by FMD under King County Code provisions concerning “financial investment properties.” For the purposes of this assessment, FMD divided the assets into asset classes (Table 2) which are either single or groupings of parcels coinciding with properties having different leases (Duwamish- Manson, - Utilities W., and -Ball-Incon properties). Because the properties are similar in site location, use, structures, exposure, and adaptation actions, the asset classes are described below separately and in the table (Table 2), but summarized overall in text when discussing sea level exposure, impact rating and adaptation actions. Where there are significant differences, these are identified.

- **Duwamish-Manson:** Manson Construction (marine construction and dredging services) leases the four northernmost parcels (10.99 acres; Parcel Identification Numbers (PINs) 1924049067, -41, -70, and -52) (Figure 4) and subleases two of the southernmost parcels (6.78 acres; PINs 1924049052 and -70) to Cadman-Lehigh as a storage and transshipment site for concrete-making materials (cement and aggregate), and for a batch plant that produces ready-mix concrete.
- **Duwamish - Utilities W.:** United Western (a foundry and abrasive products supplier) and Ardagh (recycled glass storage) occupy the middle parcel (4.67 acres; PIN 1924049051; Figure 4). The southernmost two parcels (PINs 1924049002 and 192049043) are leased by Ardagh.
- **Duwamish-Ball-Incon:** Ardagh occupies and leases out the southernmost parcel (8.76 acres; PIN 1924049002; Figure 4) for a variety of industrial and warehouse uses, including glass recycling. The J.A. Jacks subleases the northern parcel (3.38 acres; PIN 192049043) of this asset class from Ardagh Group and uses the property (and building) for construction materials storage (exposed material piles) and transshipment.

Most these properties sit in the **low exposure zone** with some areas mapped in the **medium exposure zone**, likely caused by overtopping from high water or artifacts of elevational mapping issues (Figure 4; Table 2).

The primary sea level concerns on these properties are loss of revenue in the long term, potentially environmentally hazardous materials stored on site spreading to other parcels or entering the Duwamish River (and ultimately the Puget Sound), and the financial risk that the County may be responsible under some circumstances (e.g. lease ends, lessee bankrupts) for related cleanup costs and/or penalties if the spread of potentially environmentally hazardous materials affected adjacent land or waters.

FMD has a low adaptive capacity on these properties with respect to the prohibitive costly measures to protect or repair these parcels, likely reducing revenues in the long term. While the current lease exempts the County from liability for damages from “...elements, earthquake, accident, or other casualty,” it does not specifically mention flooding or inundation, which could expose the County to liability. For these aforementioned reasons and given the moderate probability and severity of expected impacts on the properties, the Triangle properties have overall **medium impact ratings**.

King Street Center

The King Street Center (Seattle; PIN 5247800795) is an eight-floor office building occupied by multiple County agencies. The building is located about 1,500 feet east of the downtown Seattle waterfront. Of note is the building’s parking garage, the lowest floor of which is approximately one full story below street grade. The lower levels below street grade contain County and personal vehicles, a few offices, and various field equipment storage units for the occupants. In addition, the building has a water reclamation system that currently collects rainwater from the roof and intercepted groundwater seepage, keeping the runoff from adding to the burden of the City’s stormwater network. The water is collected in a large detention tank on the lowest parking level and cycled back into the building to supplement fresh water used for toilet and urinal flushing, saving 1.4 million gallons of tap water each year⁷. Water that exceeds the capacity of the detention tank is discharged into the city stormwater system by gravity flow.

⁷ <https://www.kingcounty.gov/~media/depts/dnrp/solid-waste/green-building/toolkit/commercial/king-street-center.ashx?la=en>

While King Street Center building itself is not within a mapped exposure zone, the building site has a small amount of property along the south and east perimeter that sits within the **low exposure zone** (Table 2), potentially allowing for sea water to enter the parking garage under a very high sea level rise scenario *and assumed overtopping of the seawall*. King Street Center was included in the assessment given the importance of the building to King County operations.

Additional potential sea level rise impacts on the King Street Center are marine water backflow from the city stormwater system into the lowest parking level (with overtopping of seawall), and high water events filling city stormwater drains and pipes, preventing gravity flow of excess water from the King Street Center's detention storage tank. Because there is no backflow preventer in this system, floodwater that infiltrates into the stormwater drains would cause a reverse flow into the detention tank, potentially flooding the lower level of the building.

The likelihood of overtopping of the seawall at this location is very low. Additionally, the potential for property damage and impacts on services to occupants and the public is limited. As a result, the King Street Center has a **low overall impact rating** (Table 2). Responding to possible impacts should be relatively simple and inexpensive.

3.1.1.2 Adaptation Actions: DES-FMD

FMD's adaptive capacity for sea level rise impacts varies with the asset, as described below. Because the Flour Mill and Lower Duwamish Triangle Properties are adjacent to other properties along the Duwamish River that may have similar features and sea level rise impacts, any adaptation actions by King County, the City of Seattle, or other property owners to reduce sea level rise impacts, such as building berms, would require collaboration with multiple stakeholders. It will be important to continue monitoring changes in sea level rise projections and stay connected to ongoing regional discussions about adapting to sea level rise and how these properties, especially along the Duwamish River, may be impacted and what actions would be best for the County to consider.

"Flour Mill" Properties

There are ongoing plans to repair the nonfunctional backflow valve on the discharge pipe, projected to start mid-year of 2021. This action will help to reduce current impacts from seawater flowing toward the facility during high tide and as sea level rises, limit the impacts backflow would cause. It will be important to monitor and maintain the effectiveness of this infrastructure.

Since it is and will continue to be difficult to protect this site, including the vehicular and rail access, from complete inundation, a more likely adaptive strategy would be to do little or nothing to improve the site and "absorb" the reduced revenues resulting from less critical uses or the cost of future tenants' protective efforts through lower rents.

The County could strengthen existing indemnification language in case of damage or loss of use due to high water, to include "inundation" as an explicit exception in future leases, or in amendments to current leases. In addition, if the premises or its improvements are "damaged by fire or natural disaster" and County decides to implement repairs, the County must proportionally reduce lease charges for lessee's loss of use, if any, for the duration of the disturbance. It is not clear which category sea level rise impacts would fit into.

Lower Duwamish Triangle Properties

While FMD has a low adaptive capacity for reducing/preventing damages at these properties and the possible significant revenue losses that could occur for the County and the lessees, the overall impact rating for these properties are all medium because the range of physical impacts are likely limited across the properties and the County could implement programmatic adaptation actions to reduce financial impacts to the FMD.

As sea level rise becomes more pronounced, FMD would need to consider alternatives for reducing/preventing damages if they continue to manage these assets. It could require significant investment to reconfigure these properties, whether adding fill to elevating potentially vulnerable assets, placing berms at the waterfront to prevent inundation, or building new structures higher than the elevation of the expected sea level rise or tidal surge.

For most of the assets, since it is and will continue to be difficult to protect them from complete inundation, a more likely adaptive strategy would be to do little or nothing to reduce the impacts and “absorb” the cost of future tenants’ protective efforts through lower rents. With regards to Manson properties, in light of the moderate income generated by these parcels, alternatives for reducing/preventing damage could be prohibitively costly. A more likely alternative would be to implement minimal, less expensive protection and accept reduced revenues.

A relatively easy way to significantly reduce the County’s exposure to liability would be to add more explicit language to new leases and amendments to existing leases to include impacts of sea level rise. If FMD considers selling the property, the County’s ability to sell “financial asset” properties is somewhat constrained by the King County Code provisions. However, these policies could be changed in the future.

While sea level rise is not an immediate concern for the FMD, it will be important to stay connected to ongoing regional discussions about adapting to sea level rise to inform decisions on lease renewals, for example, and the types of on-site adaptation actions that may be needed, depending on the future site uses that may limit or exacerbate indirect sea level rise impacts to adjacent lands and water.

King Street Center

The King Street Center has good adaptive capacity to protect the building from backflows caused by an overtaxed stormwater system. Retrofits to the groundwater seepage sump tank to accommodate increased seepage volumes would be cost prohibitive, but it should be relatively easy and inexpensive to install a backflow preventer valve into the discharge pipe and pump excess water from the groundwater seepage sump tank into the street. This latter action would not be suitable for long-term events.

3.1.2 King County International Airport (KCIA)

3.1.2.1 Impacts assessments: DES-KCIA

The King County International Airport/Boeing Field (KCIA; Figure 5a) sits within the tidally influenced reach of the lower Duwamish River valley and may therefore experience sea level rise indirectly via changes in daily high tides, storm surge, river flooding, and groundwater levels. KCIA is one of the busiest general aviation airports in the country, having over 165,500 takeoffs and landings each year and

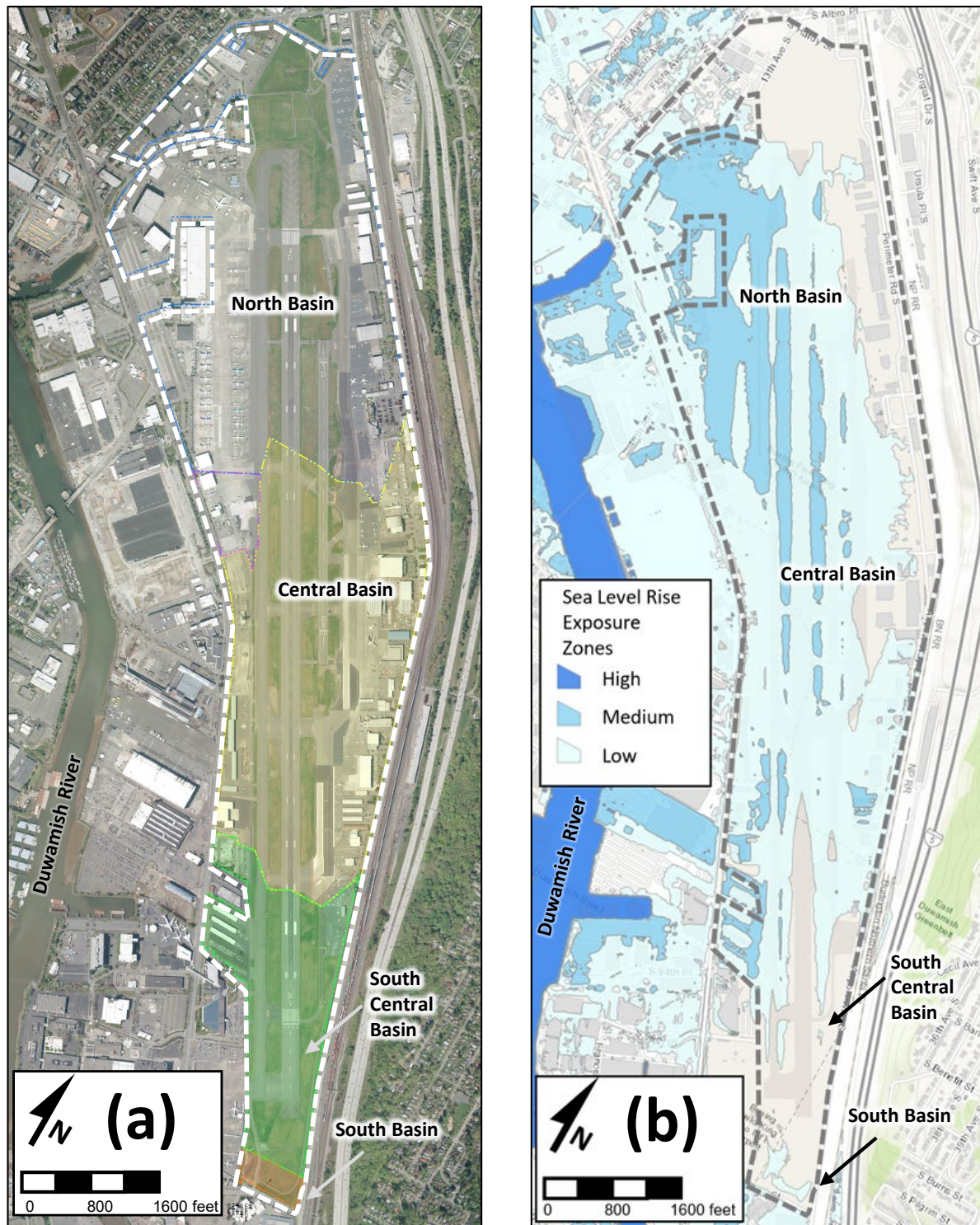


Figure 5. KCIA Asset Areas and Sea Level Rise Exposure Zones. (a) KCIA Asset Areas. The Airport is located east of the Duwamish River and is divided geographically into North, Central, South Central and South Basins. These four basins represent drainage basins that discharge to different pump stations and outfalls for the KCIA and may receive stormwater from adjacent properties. Image: KC (2014). (b) Sea Level Rise Exposure Zones at KCIA Asset Areas: North, Central, South Central and South Basins. The majority of the Airport is mapped within the low and medium exposure zones. Image: SLR and KCGIS (2018-2020).

supporting more than \$3 billion in local business sales. The 150 tenant businesses support 186,000 jobs in the regional economy and directly support over 5,200 jobs in the local economy⁸. Major airport tenants include Boeing, United Postal Service, and Signature Flying Services. The KCIA also sits within the Lower Duwamish Waterway Superfund Site, an effort overseen by the EPA and Washington Department of Ecology (WA Ecology) since 2001 to clean up contaminated river bottom sediment.

Overall, the risk of sea level rise at the KCIA is fairly limited for the range of sea level rise considered in this assessment. The majority of the airport sits in the **low exposure zone** (Figure 5b; Table 3). Operational sensitivity is high, however; any impacts to operations would need to be addressed to ensure continued reliable service. As a result of this operational sensitivity, the facility has an **overall high impact rating**. The airport has high adaptive capacity for the types of impacts identified in the assessment. Results for the assessment are described in the sections below and in Table 3.

Table 3. KCIA Exposure Zone and Overall Impact Ratings Asset Assessment Ratings.

Asset / Asset Class	General Description	Exposure Zone	Overall Impact Rating
North, Central and South Central Basin; Duwamish Valley, Seattle	Includes runway, taxiway, and ramps, stormwater conveyance and facilities, underground utilities infrastructure, aircraft washing/de-icing, and FAA airfield infrastructure in all basins. The Central Basin also supports tenant airline terminals and cargo facilities. The North Basin has airport maintenance operations and the South Basin also supports tenant aircraft storage.	LOW / MEDIUM	HIGH
South Basin, Duwamish Valley, Seattle	Includes FAA clear zone, Service Road, stormwater conveyance pipe, catch basins, and the south entrance for emergencies.	LOW	LOW

Note: Exposure zone and overall impact rating options are high, medium, or low. A high impact rating means the asset is expected to be affected by sea level rise in ways that significantly impact use of the asset.

KCIA Basins

For the purposes of this assessment, KCIA staff geographically divided the grounds into four asset areas: the North, Central, South Central, and South Basins (Figure 5a and Figure 5b). These asset areas also define stormwater drainage basins for the airport. The North, Central, and South Central Basins have many operations and activities in common, such as runways, taxiways, and ramps; stormwater conveyance and facilities; underground utilities; aircraft washing/de-icing; and Federal Aviation Administration (FAA) airfield infrastructure. Leased facilities at the Airport include corporate hangars and facilities used for aircraft testing, military equipment staging, and fixed based operations such as fueling, aircraft maintenance, and parking. The South Basin, the smallest of the four basins, is within the designated FAA clear zone. Infrastructure in the South Basin primarily consists of a service road, a stormwater conveyance pipe shared with off-site and up-gradient entities, and an emergency entrance.

⁸ Mead & Hunt. 2020. King County International Airport/Boeing Field Airport Master Plan. Draft.

https://kingcounty.gov/~media/services/airport/documents/master-plan-update/Draft_Chapter_A_Inventory.ashx?la=en

As noted above, the majority of the KCIA sits in the **low exposure zone** (Figure 5b). Some areas of the North, Central and South Central Basins are mapped in **medium exposure zones** (Figure 5a; Figure 5b; Table 3), although this may be a function of elevation rather than a direct connected to the shoreline. Airport staff noted, however, that with over 100 years of development at KCIA, there may be unknown underground storm pipes not owned by the County that could allow river water from tidal changes to reach these areas. A more detailed site review is recommended.

The primary sea level rise concern in the North and Central Basins is that with 5 feet of sea level rise, a 100-year surge event (+3 feet) has the potential to overtop the Duwamish River shoreline, leading to overland flow into large parts of the **low exposure zones** of the North Basin that would then spill into the Central Basin. In this scenario, surge water would cover parts of the runways and airport grounds, affecting tenant assets and airport operations and grounds, including taxiway and runway lights. This is a very low probability scenario and one that would only be expected towards the end of the century based on current sea level rise projections.

An additional sea level rise concern is flooding in the **medium exposure zone** due to higher river water levels getting onto the airport grounds via the stormwater outfall system. Backflow could occur into the airports complex and aging outfall system. If installed backflow preventers were to fail, this scenario would affect the basins primarily via overland flow from the North Basin and possibly via flow over East Marginal Way in the vicinity of 16th Ave S.

Impacts on the South Central Basin and South Basin are lower relative to others but it is important to remember that the airport is an integrated system; there is no foreseeable scenario where impacts would affect this basin first (or only) and not the other basins. The fact that the entire area is flat and any entry of water from any direction will affect the whole site has a large influence on the airport's sensitivity to sea level rise.

A third potential impact that is not represented in the sea level rise exposure maps is the potential for higher groundwater level due to sea level rise impacts on water levels in the lower Duwamish River. High groundwater levels are already an issue in the three northernmost basins, sometimes requiring dewatering during construction or other special considerations for underground utilities. Rising groundwater levels could impact asset functionality by reducing capacity, flooding underground infrastructure, or undermining the stability of assets designed to operate on more stable soils. Projected increases in winter rainfall could add to any increase in groundwater levels caused by sea level rise and further affect onsite drainage at the airport. Modeling projected changes in groundwater was outside of the scope of this project, making it difficult to know if and when sea level rise would affect groundwater levels at the airport.

While there are differences between each of the basins and capital improvements could be implemented to adapt to sea level rise impacts, the North, Central and South Central Basin have a **high overall impact rating** given that the basins share complex activities and the nature of operations at the site are sensitive to disruptions (Table 3). The South Basin has a **low overall impact rating** (Table 3) since there are not a lot of facilities in this basin, there is very limited potential for surge waters from other basins to reach this area, and it is easy to adapt to issues in this basin through capital improvements.

3.1.2.2 Adaptation Actions: DES-KCIA

The KCIA has high adaptive capacity for the range of sea level rise considered in this assessment, although impacts at or above the high end of the range (5 feet of sea level rise) could require more costly adjustments. A key issue is the interconnectedness of the site -- even if only a portion of one basin is impacted, operations across the entire airport could be affected to some degree. For the foreseeable future, impacts on existing pumps and taxiway/runway light wiring are not expected to be impacted by sea level rise. If needed, the KCIA could add dewatering locations or berms.

As sea level rise becomes more pronounced, the KCIA may need to install additional pumps in each basin. For example, to address the potential for flooding in the South Central Basin, the KCIA could put in a pump to discharge flood waters into the river (near 92nd). As part of the current emergency procedures for flooding in the South Basin, a portable pump is deployed at the outfall location at Slip 6. This action was performed in response to high releases from Howard Hansen Dam in 2009. A permanent pump may be considered on the opportunity to purchase available land or obtaining an easement.

In the South Basin, a higher river level would affect the ability to drain runoff from heavy rains via the current gravity feed system. Additionally, because there is no backflow preventer at this location, river water could backflow into the South Basin. The KCIA could evaluate where all known and unknown connections to the river are that would convey river flow to areas of lower elevations even when overland flow isn't possible. The KCIA could also install a pump to connect the South Basin to the South Central Basin for drainage.

The potential for higher groundwater levels in the lower Duwamish valley is another factor that could affect how soon pumping is required. Airport runway and taxiway wiring may need to be raised to incorporate changes in groundwater. If flooding or higher groundwater levels become more significant or chronic problems for operations, the KCIA could raise infrastructure (e.g. buildings and runways) to address rising flood waters or groundwater. This action would be very costly, however, and would likely only need to be considered if the very high sea level rise scenario (5 feet) becomes probable. Planned King County research on the influence of sea level rise on groundwater levels and coastal flooding (scheduled for 2021-2024) could assist the KCIA in understanding how these combined changes could impact assets at the airport.

Adaptation measures for the KCIA can be phased in as needed via ongoing capital improvements and asset management practices at the airport. Existing opportunities include the KCIA Capital Improvement Program (CIP), the FAA Master Plan, the KCIA Strategic Plan, and the KCIA Equity and Social Justice Plan. Because KCIA is governed by FAA, it may also have access to grants to implement strategies to protect the infrastructure.

More extensive site changes, if needed, would require collaboration with tenants, local jurisdictions (e.g. City of Seattle), the FAA, U. S. Army Corps of Engineers, Boeing, stakeholders, permitting agencies, and the public. In addition, it will be important to identify the interdependencies of other County agencies, to coordinate with neighboring jurisdictions and Duwamish Valley working groups (e.g. Duwamish Cleanup effort), and to work with permitting agencies (e.g. King County DLS-Permitting Division) to include sea level rise in land use and standards.

Finally, while sea level rise is not an immediate concern for the airport, it will be important to continue monitoring changes in sea level rise projections and stay connected to ongoing regional discussions about adapting to sea level rise in the lower Duwamish valley, as decisions to raise berm heights on the

lower Duwamish, for example, could change how sea level rise affects the KCIA and the types of on-site adaptation actions that may be needed.

3.2 Department of Local Services (DLS)

3.2.1 Road Services Division (Roads)

3.2.1.1 Impacts Assessments: DLS-Roads

King County’s Road Services Division (Roads) is responsible for almost 1,500 miles of unincorporated roadway, 182 bridges, and related infrastructure such as sidewalks and pathways, bike lanes, guardrails, drainage facilities, traffic control equipment, and traffic cameras. This widespread infrastructure network enables travel between cities and other counties, as well as within unincorporated communities. County roads and bridges are necessary links for the movement of people, utilities, and goods throughout the most urban and dense county in the state. Ongoing Roads funding shortages have resulted in insufficient funding to maintain and replace many King County roads and bridges, creating potential future challenges for regional and local connectedness.

Sea level rise is projected to impact a very small fraction of the overall unincorporated King County road network. By 2100, sea level rise modeling suggests that approximately 2.5 miles of shoreline road segments on Vashon and Maury Island may be impacted to varying degrees depending on location (road segments cross **low**, **medium**, and **high exposure zones**; Table 4). This total comprises slightly less than 2 percent of the total roads on Vashon and Maury Island and approximately 0.1 percent of the total unincorporated King County road system. There are no road bridges projected to be impacted by sea level rise.

Table 4. Roads Services Division Asset Assessment Exposure Zone and Overall Impact Ratings.

Asset / Asset Class	General Description	Exposure Zone		Overall Impact Rating
Shoreline arterial segments on Vashon-Maury Island	By 2100, approximately 2.5 miles of shoreline arterial and local road segments, or 2 percent of the 132 miles of roadway managed by Roads on Vashon and Maury Island, are projected to be impacted by rising sea levels. These road segments are located within the projected low, medium and high sea level rise exposure zones. Less than ½ mile of these impacted shoreline road segments are located on Dockton Road and SW Quartermaster Drive, two higher volume arterials. All road segments likely to be exposed to rising sea levels have detours available, with the exception of the connections between Vashon and Maury Island.	Road segment exposure zones vary depending upon location	HIGH	HIGH (Vashon Maury Island connector roads only)
			MEDIUM	
			LOW	

Note: Exposure zone and overall impact rating options are high, medium, or low. A high impact rating means the asset is expected to be affected by sea level rise in ways that significantly impact use of the asset.

While there are differences in exposure ratings and options for managing sea level rise impacts on affected road segments, the overall impact rating for shoreline arterial road segments on Vashon-Maury Island is considered **high** given current King Tide/storm surge impacts on low-lying portions of Dockton and SW Quartermaster roads, specifically in the vicinity of the isthmus that connects Vashon and Maury Islands, and the potentially high costs of addressing sea level rise impacts on affected road segments.

All road segments projected to be impacted by sea level rise have road detour options with the exception of the short segments of Dockton Road SW and SW Quartermaster Drive located on the isthmus that connects Vashon and Maury Islands (Figure 6). The highest sea level rise impact rating is aligned with a short segment of SW Quartermaster Harbor Drive, in the southeast portion of Vashon Island. During current extreme high tides, this short road segment experiences water on and at times, over the roadway.

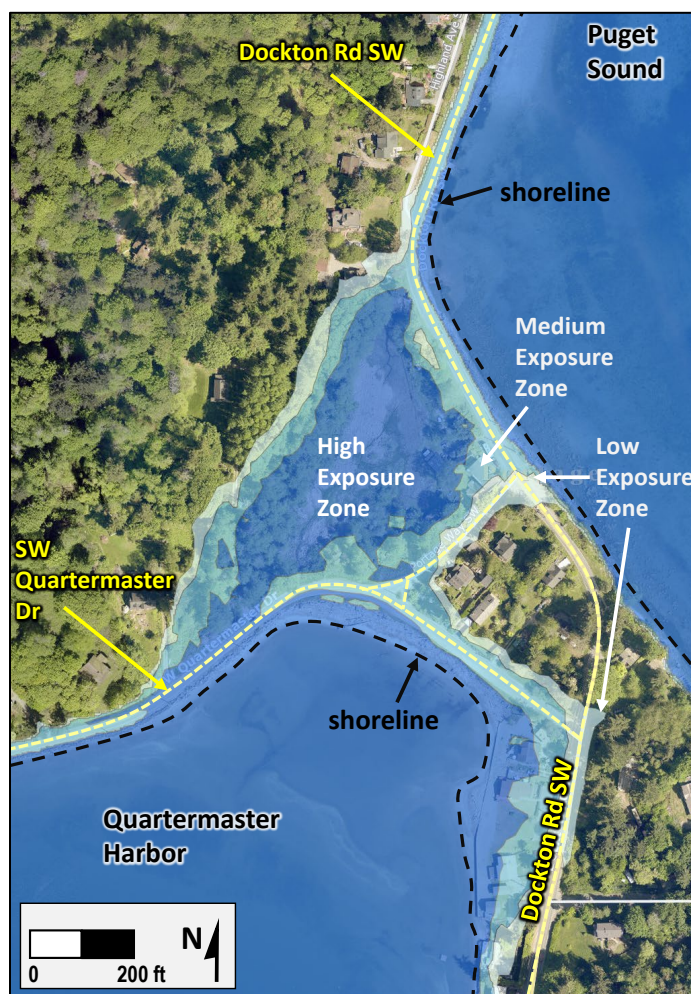


Figure 6. Sea Level Rise Exposure Zones in the Dockton RD SW and SW Quartermaster Harbor DR Area. Image: SLR and KCGIS (2018-2020).

3.2.1.2 Adaptation Actions: DLS-Roads

DLS capacity to adapt impacted roads to sea level rise is currently very limited due to funding constraints. Critical life safety is a strategic priority. Emergency preparedness and ongoing monitoring characterize the agency’s current approach to managing an underfunded road system in decline. King County road crews monitor SW Quartermaster Drive and all other vulnerable road segments during storm events and extreme high tides. As needed, Roads crews place ‘water over roadway’ signs to alert the traveling public of emergent conditions (Figure 7). Less frequently, road segments are temporarily

closed due to water over the roadway and crew place 'road closed' signs on the impacted roads. Temporary road closures are communicated more broadly through the King County Roads "My Commute" website.

In addition to impacting the safety of the traveling public, repeated water exposure can damage and erode roads and related infrastructure, ultimately leading to either temporary or permanent road closure. A subset of unincorporated King County roads, including some of the Vashon-Maury Island road segments that are projected to be impacted by sea level rise, have suffered repeated failures over time and have required repeated repairs following storm or prolonged rain events.

Many of King County's identified vulnerable road segments require exceptionally expensive and/or frequent repairs. Given the ongoing financial crisis with King County Roads, more significant adaptive measures (e.g., raising road elevations, moving roads, or building causeways) are not an option at this time. Vulnerable road segments, such as those projected to be impacted by sea level rise, will continue to be closely monitored for safety and lane restricted or temporarily closed as needed until emergency repairs are completed.



Figure 7. High Tide During a Storm Event (January 04, 2021). Overtopping of Quartermaster Drive and Inundation of Adjacent Property. Photo: KC Staff (G. Rabourn)

3.2.2 Metro Transit Department (Metro)

3.2.2.1 Impacts Assessments: Metro

The King County Metro Transit Department (Metro) provides a wide range of transportation options and choices for King County. Travel options include an extensive bus network, Rideshare, Access Transportation, the King County Water Taxi, and other services designed to King County’s growing transportation needs. Metro also operates the Seattle Streetcar and Sound Transit’s regional ST Express bus service and Link Light Rail.

Metro owns, operates, and/or manages a wide diversity of assets as part of its service portfolio. Given the time horizon for this sea level rise assessment, several asset categories were excluded from the assessment. This included Metro’s numerous bus routes, bus stops, and comfort stations crossing through or located in the mapped sea level rise exposure zones. While important to Metro services, these assets are regularly changed due to inclement weather, road construction, and schedule changes. It is assumed that the identified routes and stops will be adjusted as needed if still located or crossing through areas experiencing sea level rise impacts. The Seattle Streetcar and Sound Transit’s regional ST Express bus service and Link Light Rail were also excluded since the County does not own these assets.⁹

The remaining Metro assets included in this assessment are four buildings (South Annex Base buildings South Safety & Training Building A and South Design & Construction Building B; Metro Transit Police Building; Waterfront Streetcar Rectifier), a leased park and ride location on SW Spokane Street, and the Water Taxi. Given the overall low number of Metro assets located in the sea level rise exposure zones and the finding that none of these assets have a high overall impact rating, Metro’s risk to sea level rise is considered limited. Results for the assessment are described in the sections below and summarized in Table 5.

Table 5. Metro-Transit Department Asset Assessment Exposure Zone and Overall Impact Ratings.

Asset / Asset Class	General Description	Exposure Zone	Overall Impact Rating
Building - South Annex Base: 11911 East Marginal Way S, Seattle	Transit Annex includes the South Safety & Training Building A, South Design & Construction Building B, parking, and storage areas.	MEDIUM	MEDIUM
Building and Substation - Waterfront Streetcar Rectifier: 1920 Alaskan Way, Seattle	Former electrical substation for the streetcar. Deactivated equipment can be used, if needed, for future electric bus charging.	LOW	LOW
Building - Metro Transit Police Building: 5303 1st Ave S, Seattle	Leased building providing transit police services.	LOW	LOW
SW Spokane Street Park and Ride: 3599 26th Ave SW, Seattle	Leased from Washington State Department of Transportation.	LOW / MEDIUM	LOW
Water Taxi Ferry Service - Two routes between downtown Seattle and West Seattle or Vashon Island.	Three ferries; a terminal and a floating maintenance facility at Pier 48 and Pier 50 in Seattle; and floating docks at the Vashon Ferry Terminal and Seacrest Park in West Seattle.	HIGH	LOW

Note: Exposure zone and overall impact rating options are high, medium, or low. A high impact rating means the asset is expected to be affected by sea level rise in ways that significantly impact use of the asset.

⁹ Sound Transit completed a [comprehensive climate change risk assessment](#) for Sounder, Link, and ST Express in 2013.

Metro Buildings & SW Spokane Park-and-Ride

Relative to other assets evaluated in this assessment, the South Annex Base (also referred to as the Transit Annex; Figure 8) is Metro's most impacted fixed asset with a **medium overall impact rating** (Table 5). Located in the **medium exposure zone**, the South Annex Base consists of two buildings, parking, and storage areas. The site is currently used for trainings and as a storage yard for buses and spare shelters. The site also includes disposal processes for stormwater drain cleaning. Services provided at the site are in the process of shifting with construction of a new south bus base.

The primary pathway for water is from increased tidal flooding in the lower Duwamish waterway via hydrologic connectivity from a creek that adjoins the property and drains to the Duwamish river. Notable but still limited flooding starts to appear at four feet of sea level rise, or lower levels when including storm surge. Other concerns include potential damage to equipment, supplies (salt and sand), and the building, depending on the duration and extent of flooding. Increased flooding on the site would require notable but manageable adjustments in how materials are stored onsite and potential changes in stormwater treatment. The transition of some services and functions to the new South Base may help reduce the sensitivity of the site to sea level rise impacts.

The three remaining assets in this class for Metro bus transit and related services are in **low exposure zones** and have **low overall impact ratings** (Table 5). The future use of the Waterfront Streetcar Rectifier building and deactivated streetcar substation on Alaskan Way is uncertain. If impacted by sea level rise, potential plans for using the site for battery bus charging could be relocated or the asset could be sold or decommissioned. The Metro Transit Police Building on 1st Avenue South in Seattle is a leased space providing transit police services. Any impacts are likely to be short term or infrequent. If any chronic issues were to emerge, Metro could terminate the lease and move services. Leased parking for transit riders at the SW Spokane Street Park and Ride could be limited during periods of flooding, however Metro would be able to relocate services if flooding became a more chronic issue.

Water Taxi

The King County Water Taxi provides full commuter service on two routes from the Seattle waterfront, to West Seattle and Vashon Island. The Water Taxi system includes three ferries (two 278 and one 150 passenger only ferries); floating docks at Seacrest Park in West Seattle (Figure 9a) and the Vashon Ferry Terminal (Figure 9b); and the Pier 50 terminal (Figure 9c) and floating maintenance facility at Pier 48 (Figure 9d) in Seattle. The Vashon and West Seattle locations are leased from Washington State Department of Transportation (WSDOT) and the City of Seattle. Pier 50 was built in 2019. The maintenance dock was built in 2012.

The Water Taxi provides an unrestricted transit option during construction or road closures, such as the Alaskan Way Viaduct and West Seattle Bridge. During emergencies it can move first responders to the scene and evacuate residents. The Water Taxi's current six-year plan includes phased construction of a mobility hub in West Seattle that would add parking, a shuttle waiting area, shoreside infrastructure and a floating pier. A Ballard water taxi route is in the proposal phase and would use leased dock space in Shilshole Marina.

The Water Taxi passenger ferry terminal docks are located on the shoreline out of necessity, placing these facilities in the **high exposure zone** (Table 5). The facilities have a **low overall impact rating**, however, due in part to the design of Water Taxi infrastructure. At Pier 50 (and Vashon), for example, pile guides allow for 10 feet of affordable rise to accommodate changes in tidal elevation and waves.

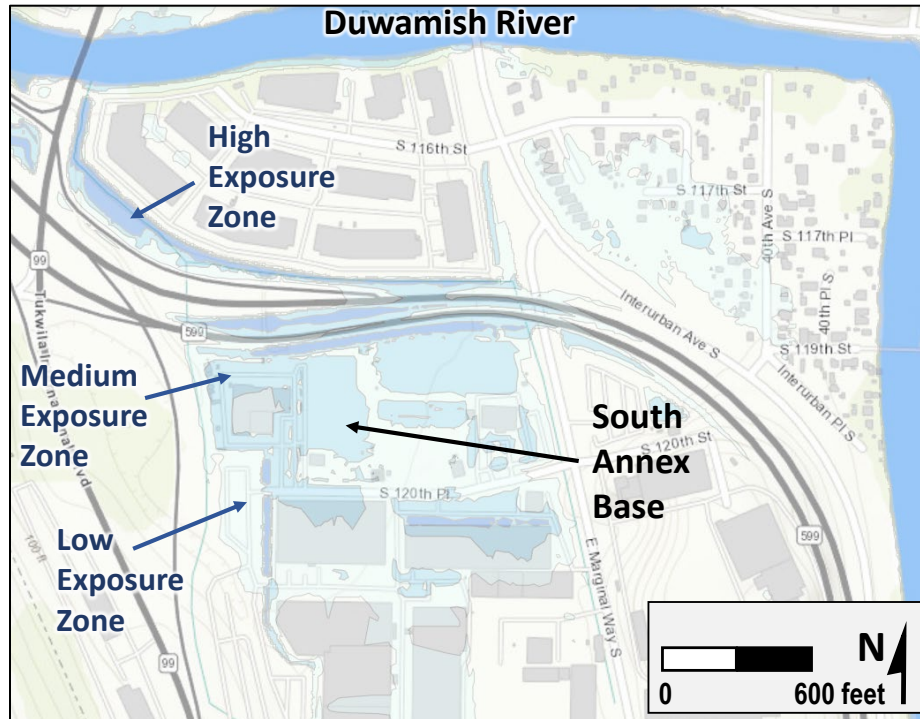


Figure 8 Sea Level Rise Exposure Zones at South Annex Base: South Safety & Training Building A and South Design & Construction Building B. Medium and Low exposure zones are present across the site, impacting access to buildings, parking and storage areas. *Image: SLR and KCGIS (2018-2020).*

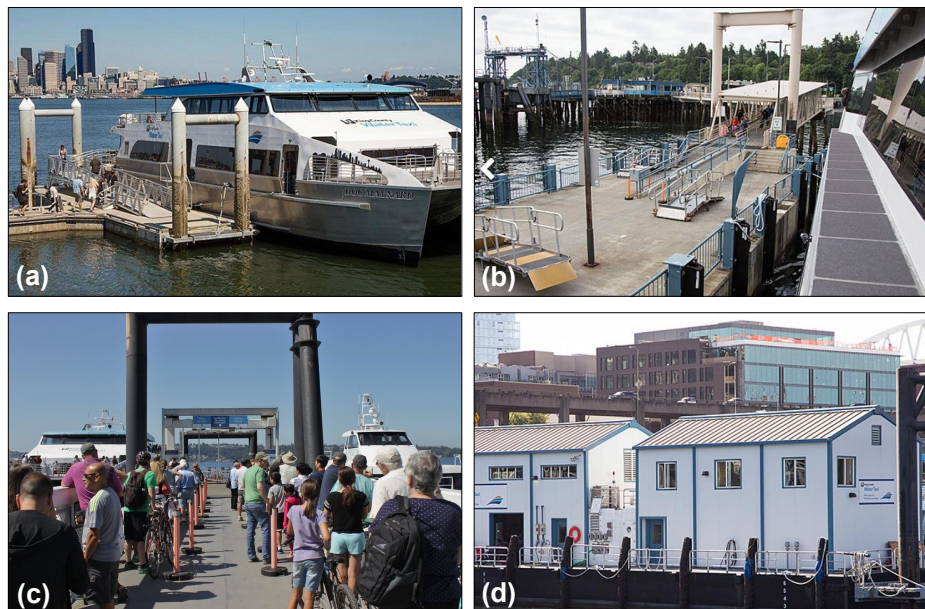


Figure 9. King County Water Taxi Facilities. (a) West Seattle-Seacrest Park. Passengers loading onto the MV Doc Maynard via the floating dock. (b) Vashon Island water taxi floating dock. In the background, the WSDOT ferry terminal is visible. (c) Pier 50, Seattle. Passengers lined up for loading onto the water taxi. (d) Downtown terminal, Seattle. Maintenance Barge. *Photos: KC Staff (N. Ahrens)*

Additionally, the office floor at the Pier 50 terminal was raised six inches to account for near-term sea level rise concerns and a four-foot wave wall was built to protect against the 100-year storm event.

One near-term impact noted by staff is the impact of higher water levels on gangways and facility access, including the maintenance facility at Pier 48 and Vashon. Gangway access could be restricted as sea level rises but the gangway can be adapted to account for higher water levels. Wind events and King Tides can also slow operations by putting more flotsam in the water, and any north wind and wave action above 30 knots will shut down services. It is easy to re-route passengers during service disruptions, however, using state ferry boats (where co-located) or Metro bus service.

While given a low overall impact rating, Water Taxi facilities at West Seattle (Seacrest Park) are likely to be affected by sea level rise sooner relative to other Water Taxi facilities and therefore require earlier adaptive action. The West Seattle float pile guides, originally designed more for recreational purposes, only have about seven feet of affordable rise. This location is also more susceptible to north wind events, resulting in wave action and potential flooding. Temporary closures related to flooding are already possible with 10 to 12-foot tide levels and wind-driven events. Increased tidal flooding would also impact access and use of the parking lot and shuttles, including areas slated for planned upgrades. Gangway access would also be affected by higher water levels but those changes could be easily accommodated.

3.2.2.2 Adaptation Actions: Metro

Overall, Metro has high adaptive capacity for addressing potential sea level rise impacts on the assets included in this assessment. This finding is also true for potential impacts to routes and stops, which are regularly adjusted in response to extreme weather events and planned service changes.

Buildings & SW Spokane Park-and-Ride

The South Annex Base has good adaptive capacity for minimizing damage to what is stored on site, although there are some limits to what could be done to protect the building from inundation and other impacts. Increased flooding on the site would require notable but manageable adjustments in how materials are stored onsite (e.g. moving or raising storage). Options for mitigating damage to the building are limited to installing a coffer dam. If onsite stormwater treatment is affected, Metro would have to look at alternate methods of disposal. The transition of some services and functions to the new South Base is likely to reduce the sensitivity of the site to any sea level rise impacts.

Any need to adapt the Waterfront Street Car Rectifier site is contingent on future decisions related to the location of battery bus charging stations. If the site is impacted, Metro could relocate services or adapt the site for other uses. The asset could also be sold or decommissioned.

Short term adaptive actions for the leased Metro Transit Police Building could include temporary relocation of services (e.g., if access is an issue). If flooding were to become a more chronic issue, Metro could terminate the lease and move services to another location.

Adaptive actions for flooding at the SW Spokane Street Park and Ride could include changing pickup locations for the duration of a flooding event or finding alternative short-term locations for parking (e.g., via lease agreements with places having mostly empty parking lots during weekday working hours). If chronic issues were to occur, Metro could permanently relocate parking services.

Water Taxi

Water Taxi infrastructure is already designed to and/or can be easily updated to accommodate variations in tide heights. Relatively minor modifications, including raising gangway elevations and pile guides, would be needed at current locations to account for sea level rise. Any issues with more frequent flotsam would be managed by slowing crossing speeds, as is currently done. In the event of more boat cancelations, it is easy to re-route passengers to the larger Washington State ferries or Metro bus service.

3.3 Department of Natural Resources and Parks (DNRP)

3.3.1 Parks Division (Parks)

3.3.1.1 Impacts Assessments: DNRP-Parks

The Parks Division (Parks) manages 200 parks, 175 miles of regional trails, and 215 miles of backcountry trails on more than 32,000 acres in King County. Parks properties include extensive natural areas and beaches as well as ballfields, playgrounds, docks, pools, and other facilities.

Overall, the risk to sea level rise for Parks assets is fairly limited even though all fifteen natural areas and parks along the Vashon and Maury Island shoreline evaluated for this assessment are located within the mapped sea level rise exposure zones (Table 6). All of the sites sit at least in part within the **high exposure zone**. The overall impact rating for the sites varied, however, due primarily to differences in built amenities and site uses. Dockton Park and Natural Area, combined for the purposes of this assessment, had a **high overall impact rating**. Three properties were rated **medium** and the remaining ten had **low overall impact ratings**. Results for the assessment are described in the sections below and summarized in Table 6.

Common sea level rise concerns for Parks properties are shoreline inundation and nearshore flooding, loss of land area from rising tides, limited space for habitat retreat, and reduced access or impairment of public amenities. Impacts on natural areas are less of a concern. These areas are designated for habitat preservation and passive recreation. The intent is to allow those sites and the habitats they support to adapt naturally to sea level rise.

Dockton Park and Natural Area

Dockton Park (Figure 10), located in Quartermaster Harbor, is the Parks facility most impacted by sea level rise. Dockton Park already experiences flooding in the parking lot and overtopping of the bulkhead during King Tides and storm surge events (Figure 11a and Figure 11b). Areas along the southwestern part of the property also experience tidal flooding.

Dockton's use as a multi-purpose recreation site is significantly impaired with 2 feet of sea level rise, resulting in a **high overall impact rating** for the site. Key concerns are impacts on built amenities and services, reduced public access, and limits on relocating infrastructure with higher amounts of sea level rise. Potential impacts on use of this site as an emergency access point during regional catastrophic events (e.g., an earthquake) and the complexity of potential environmental impacts to sensitive herring populations also factored into this rating.

Table 6. Parks Division Asset Assessment Exposure Zone and Overall Impact Ratings.

Asset / Asset Class	General Description	Exposure Zone	Overall Impact Rating
Dockton Park and Natural Area* , Maury Island	Dockton Park (20.68 acres) includes a destination marina, large dock, pier, moorage, two bathroom facilities, a picnic area, bulkhead, boat launch, and a parking lot. The adjoining Dockton Natural Area is a restored salt marsh that provides critical habitat for herring spawning.	HIGH	HIGH
Ellis Creek Natural Area , Vashon Island	Passive recreation site ¹⁰ includes a pocket estuary (connected to Puget Sound by a culvert under Dockton Road). This site is particularly important for juvenile Chinook and chum for rearing, refuge from predators, and transition to saltwater habitats.	HIGH	MEDIUM
Forest Glen Natural Area , Vashon Island	This 3.76-acre site is a relatively sloped property with a bluff backed beach and is used for passive recreation and wildlife habitat.	HIGH	MEDIUM
Raabs Lagoon , Quartermaster Harbor	Passive recreation site ¹⁰ with a lagoon that drains onto the beach through a cut in the bulkhead. Outgoing tides creates a mini-waterfall at the mid to low tides.	HIGH	MEDIUM
Bluff Back Natural Areas (8 sites), Vashon Island	Multiple habitat preservation and natural shoreline restoration sites: Inspiration Point, Lost Lake, Manzanita, Maury Island, Neill Point, Northilla Beach, Piner Point, and Point Heyer Natural Area.	HIGH	LOW
Spring Beach Natural Area , Vashon Island	25-acre passive recreation site ¹⁰ . This bluff backed area includes a freshwater wetland.	HIGH	LOW
Maury Island Marine Park , Vashon and Maury Islands	Once a former gravel pit, this 300-acre park offers beachcombing, hiking, primitive campsites, heron and eagles nesting, and a kayak rack near the shore.	HIGH	LOW

Notes: Exposure zone and overall impact rating options are high, medium, or low. A high impact rating means the asset is expected to be affected by sea level rise in ways that significantly impact use of the asset. *Dockton Natural Area as a natural area would have an overall lower impact rating. Because Parks manages Dockton Natural Area and Dockton Park as an integrated asset, the overall rating is high.

While less affected in many ways relative to Dockton Park, the adjoining Dockton Natural Area was combined with Dockton Park at the recommendation of Parks staff and therefore also shares the Park's **high overall impact rating**.¹¹ Large parts of Dockton Natural Area will experience increased tidal flooding and permanent inundation with 2 and 5 feet of sea level rise. Habitat in the low-lying estuary has limited space to move back and will be permanently inundated with 5 feet of sea level rise but the remaining treed upland area should still provide habitat. Impacts on habitat quality and its continued role as an important herring spawning site are unknown. Any future decisions related to adapting Dockton Park and Dockton Road may positively or negatively affect the adaptive capacity of this natural area.

Natural Areas

Ellis Creek Natural Area, Forest Glen Natural Area, and Raabs Lagoon each have a **medium overall impact rating** (Table 6). While these natural areas are mostly used for wildlife and habitat preservation and the future intent is to let sea level rise take its course, the impacts and/or ability to adapt to issues

¹⁰ Passive recreation refers to activities such as camping, hiking, wildlife viewing, observing and photographing nature, picnicking, walking, bicycling, running, horseback riding and fishing. Passive recreation facilities do not require significant levels of infrastructure or development ([King County 2013](#))

¹¹ If assessed separately, Dockton Natural Area would have a medium overall impact rating for the reasons noted above.

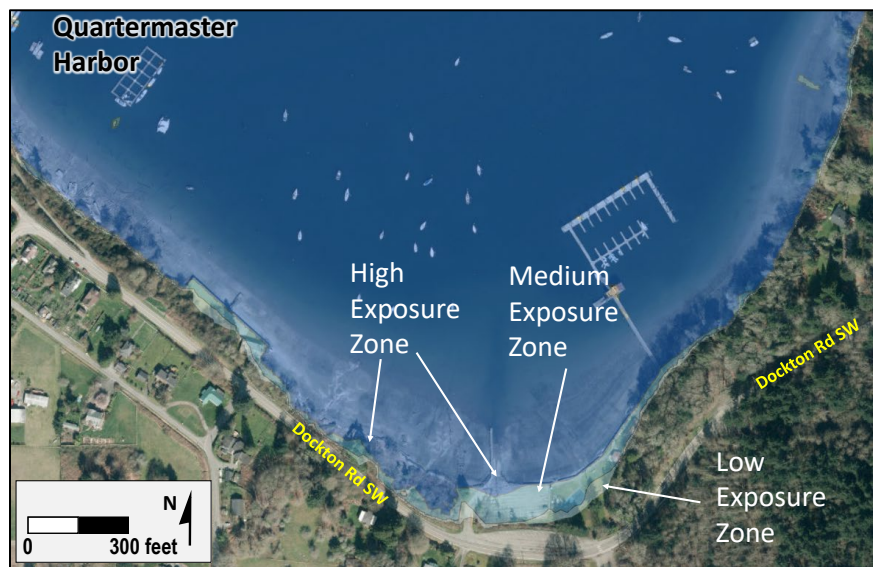


Figure 10. Sea Level Rise Exposure Zones at Dockton Park, Quartermaster Harbor, Maury Island. Shoreline is inundated and nearshore flooding occurs at this site, including access to the pier in the high exposure zone. Image: SLR and KC Aerial Map (2012).



Figure 11. High Tide at Dockton Park During a Storm Event (January 04, 2021), Quartermaster Harbor, Maury Island. (a) Water reached top of bulkhead and bottom of the pier. (b) Dockton Park Boat Ramp is overtopped and water inundates above the ramp bulkhead. Photos: KC (G. Rabourn).

associated with the impacts had enough complexity to warrant a medium overall impact rating. Noted issues for each site included the following:

- *Ellis Creek Natural Area*: Nearshore areas in the Ellis Creek Natural Area will be inundated as sea level rises and passive recreation at the site will be somewhat impaired. While there is room for the habitat to move backwards and adapt, that ability is potentially limited by the adjoining source water springs for Water District 19. Water District 19 may need a barrier to protect their

springs, which serve as a water source for the largest Group A Public Water System on Vashon Island. Resulting impacts on habitat quality are not known.

- *Forest Glen Natural Area*: The shoreline portion of the Forest Glen Natural Area will see increased tidal flooding and inundation with 2 and 5 feet of sea level rise. Remaining grass and treed upland areas are still expected to provide space for passive recreation, however. While the adaptive capacity for this area is improved with removal of the site's bulkhead in 2018, King County-owned armoring that protects adjoining properties and infrastructure will need to be monitored and maintained.
- *Raabs Lagoon*: The main concerns at Raabs Lagoon are the current overtopping of the bulkhead during King Tides, slide/erosion problems along high bank areas that can affect private property, and inundation of large portions of the site at 2 and 5 feet of sea level rise. Remaining grass and treed upland areas will still allow for passive recreation at the site even with 5 feet of sea level rise. The future of the aging bulkhead is uncertain and likely to be a political challenge.

The remaining natural areas – eight bluff backed natural areas, Spring Beach Natural Area, and Maury Island Marine Park – have a **low overall impact rating**. These areas were acquired or otherwise designated for habitat preservation and passive recreation. The intent is to let sea level rise and nature takes its course. In nearly all cases, passive recreation is still possible even with 5 feet of sea level rise. Parks staff noted that conservation of the freshwater wetland at Spring Beach to a brackish wetland would be beneficial; brackish wetlands are a rare habitat for the area.

3.3.1.2 Adaptation Actions: DNRP-Parks

Parks' adaptive capacity for addressing sea level rise impacts is site dependent. In all cases, Parks staff determined that protecting Parks properties "as is" was not an option. In most cases, the intent is to let sea level rise take its course with little additional action. In some cases, passive or active recreation amenities will be abandoned or relocated. Potential adaptation actions for specific sites are summarized in Table 7.

3.3.2 Water and Land Resources Division - Stormwater Services (WLRD-SWSS)

3.3.2.1 Impacts Assessments: WLRD-SWSS

The King County Stormwater Services Section (SWSS) assessed two sets of stormwater facilities to determine potential impacts from sea level rise. The two facilities sets are the Hamm Creek Sediment Pond facility (Figure 12) and the Burns Avenue Drainage facility.

Overall, the risk of sea level rise for SWSS is very limited due to the low number of assets located in the sea level rise exposure zones and the limited impacts on these assets. Results for the assessment are described in the sections below and summarized in Table 8.

Hamm Creek Sediment Pond Facility

The Hamm Creek Sediment Pond facility (Figure 12) includes several individual assets; one overflow catch basin, two pipes, two culverts and one sediment pond. The facility conveys stream flows through two culverts under an access road and provides bypass to reduce flooding to the road. The channel carrying Hamm Creek is parallel to West Marginal Place South and State Route 99 and eventually outfalls

Table 7. Parks Division Adaptations Actions/Considerations.

Asset / Asset Class	Potential Adaptation Actions / Considerations
<p>Dockton Park and Natural Area, Maury Island</p>	<p>Options include:</p> <ul style="list-style-type: none"> • Adapt infrastructure design to accommodate sea level rise, e.g., elevate facilities and infrastructure, build moveable infrastructure. • Relocate infrastructure upslope as much as possible with goal of preserving as many of the existing uses as possible (note: options are more limited at 5 feet of sea level rise). • Remove infrastructure and downshift supported recreation uses at the site. • Change the elevation of the shoreline (backshore) with beach nourishment. Remove bulkhead and armoring as part of this process to build a more natural shoreline. <p>Additional considerations:</p> <ul style="list-style-type: none"> • Adaption choices for Dockton Road and Dockton Park could create unintended consequences for the Dockton Natural Area. Parks will need to monitor for this. • Adaptation of Dockton Park may affect, or be affected by, decisions related to Dockton Road. Coordination with DLS Roads will be required.
<p>Ellis Creek Natural Area, Vashon Island</p>	<ul style="list-style-type: none"> • No adaptive action anticipated, with exception of potential need to protect the adjoining natural springs water source under a high sea level rise scenario. Will otherwise let the site adapt naturally. • Will need to coordinate with DLS Roads on any changes to the culvert or Dockton Road that may affect the natural area.
<p>Forest Glen Natural Area, Vashon Island</p>	<ul style="list-style-type: none"> • No adaptive action anticipated. Will let the site adapt naturally. • Continue monitoring remaining armoring (wing walls) at property boundaries to ensure that adjoining properties are being protected.
<p>Raabs Lagoon, Quartermaster Harbor</p>	<ul style="list-style-type: none"> • No adaptive action anticipated, pending future decisions regarding the aging bulkhead at the entrance of the lagoon. Intent is to let the site adapt naturally.
<p>Bluff Back Natural Areas (8 sites), Vashon Island</p>	<ul style="list-style-type: none"> • No adaptive action anticipated. Will let the sites adapt naturally.
<p>Spring Beach Natural Area, Vashon Island</p>	<ul style="list-style-type: none"> • No adaptive action anticipated. Will let the site adapt naturally. • Could help expedite the expected freshwater transition to a brackish wetland, given the benefits of this rare habitat type.
<p>Maury Island Marine Park, Vashon and Maury Islands</p>	<ul style="list-style-type: none"> • Where passive recreation infrastructure is affected, Parks could relocate infrastructure upslope as much as possible with goal of preserving as many of the existing uses as possible and/or remove infrastructure and downshift supported recreation uses at the site.

to the Duwamish River. The settling pond settles sediment so that the culvert does not get blocked with debris and sediment.

The Hamm Creek Sediment Pond facility is located in the **medium exposure zone** (Figure 12; Table 8). In the event of a large storm, on top of increased sea level rise, the catch basin could overflow and the sediment pond could become flooded and be obsolete, potentially flooding to the West Marginal Place South neighboring portion of the road with possible flooding damage to the highway. This sediment pond facility is rated overall with a **medium overall impact rating**. If the sediment pond was underwater, and unable to function as it was intended, there would be a need for a large scale retrofit that would require potential partnerships with King County Roads, WSDOT, Seattle Department of Transportation, and may require a capital improvement plan. The current adaptive capacity to conduct that work would be low.

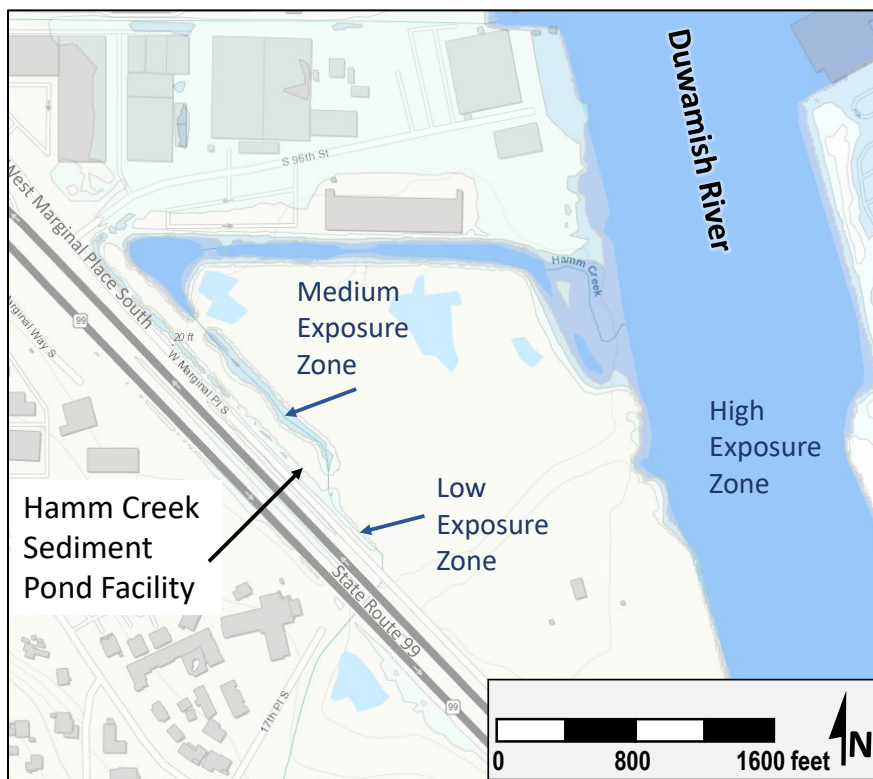


Figure 12. Sea Level Rise Exposure Zones at Hamm Creek Sediment Pond Facility. In the event of a large storm, on top of increased sea level rise (SLR), the catch basin could overflow and the sediment pond could become flooded. This has the potential to cause flooding to the West Marginal Place S. neighboring portion of the road. This assessment presumes that the site culvert could be impacted by two feet of SLR and the sediment pond could be impacted by five feet of SLR. *Image: SLR and KCGIS (2018-2020).*

Table 8. Stormwater Services Section Asset Assessment Exposure Zone and Overall Impact Ratings.

Asset / Asset Class	General Description	Exposure Zone	Overall Impact Rating
Hamm Creek Sediment Pond Facility DR0513, West Marginal Place S.	Facility includes one overflow catch basin, two pipes, two culverts and one sediment pond.	MEDIUM	MEDIUM
Burns Avenue Drainage Facility DR0505, near Des Moines Memorial Drive S.	Facility includes one culvert and one pipe. A channel carries natural drainage from a manhole on 10 th Ave. S. to culverts under Des Moines Memorial Dr. S. A small section of culvert is the main asset within this facility.	LOW	LOW

Note: Exposure zone and overall impact rating options are high, medium, or low. A high impact rating means the asset is expected to be affected by sea level rise in ways that significantly impact use of the asset.

Burns Avenue Drainage Facility

The Burns Avenue Drainage facility includes one culvert and one pipe. There is a channel that carries natural drainage from a manhole on 10th Avenue South to culverts under Des Moines Memorial Drive South. A small section of culvert is the main asset within this second facility.

The Burns Avenue Drainage facility is within a **low exposure zone** (Table 8). During a high tide and large rain event, there may be inundation of the culvert, with potential for erosion. This drainage facility is rated with a **low overall impact rating** due to being mapped in the **low exposure zone** and the facility will likely continue to function as designed if inundated from sea level rise. While the facility may be inundated from sea level rise, there are no known negative consequences to the functionality of the individual assets, but increased erosion is a potential outcome.

3.3.2.2 Adaptation Actions: WLRD-SWSS

Hamm Creek Sediment Pond and the Burns Avenue Drainage facility are located in the South Park/Duwamish Valley region of King County. This area has historically been considered underserved, with South Park consistently referred to as the most polluted neighborhood in Seattle. Many residents live close to industrial sites, many of which contribute to various air and water pollution. Conducting an impact assessment on these facility assets allowed SWSS to review potential future negative consequences of sea level rise and identify actions that will prepare the area for the impacts and increase resiliency to the properties. Data driven decisions and resiliency planning to these parcels will have a long-term benefit to the surrounding communities and their residents.

The SWSS proposes the adaptation actions described in Table 9 for Hamm Creek Sediment Pond and Table 10 for the Burns Avenue Drainage facility. The two actions highlighted in bold text for both assets will mainstream actions into program decision processes within SWSS.

The County holds a Phase I Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) permit, requiring the use of a Surface Water Design Manual (SWDM) for stormwater facility designs. The County's SWDM has been approved for use by WA Ecology. Several Phase I and Phase II permitted jurisdictions also adopt the County's SWDM for use in their city or county. The manuals are updated approximately every five years, the same schedule as updated NPDES permits. King County will be adding information in the next SWDM update regarding future rainfall projections under various climate change scenarios to ensure stormwater facilities are designed appropriately to handle changes in rainfall. During that update, adding sea level rise consideration assessments as a requirement of the SWDM will increase awareness of potential sea level rise impacts to stormwater facilities and mainstream the process for builders to consider where and how sea level rise might impact their development.

In addition, the SWSS Capital Program could develop a plan to require all stormwater capital improvement projects to determine if they are within or near the sea level rise inundation zones and if so, require the completion of a sea level rise impact assessment to determine how the project will be impacted by sea level rise or how the project can increase resiliency to sea level rise in the future. This action would increase awareness of sea level rise impacts and locations of impact for the Capital Program and allow the program to mainstream decisions around sea level rise impacted projects.

In addition to these actions, the next steps for SWSS are to:

- Increase inspection and monitoring frequency during high tide events at both the Hamm Creek Sediment Pond site and the Burns Avenue Drainage site to gather evidence of potential sea level rise impacts to the facility assets.
- Work with Roads to ensure consistency in SWSS' and Roads' responses to stormwater facilities that are impacted by sea level rise but are managed separately by each agency.

Table 9. Hamm Creek Sediment Pond Facility Adaptation Actions / Considerations.

Action Type	Potential Adaptation Actions / Considerations
No Regret	<ol style="list-style-type: none"> 1. Increase inspections and monitoring during high tide events to identify areas of erosion and sedimentation loading. 2. Collaborate with Parks, WLRD, Roads, and other divisions interested in potential future projects on or near the parcel to understand barriers and opportunities.
Low Regret	<ol style="list-style-type: none"> 1. Add a flood gate to the outfall. 2. Develop a draft scope for a future retrofit to the sediment pond in the event that sea level rise reduces the function of the assets. Have a discussion with Roads, WSDOT and City of Seattle regarding impacts to surrounding roads, in order to understand each of the agency's plans to address sea level rise in the area. 3. Adding sea level rise considerations as a requirement of the Surface Water Design Manual's updated version to increase adaptive capacity. 4. Develop a plan to require stormwater capital improvement projects to complete an impact assessment if a project is in or near the sea level rise inundation zones.
Co-Benefit	<ol style="list-style-type: none"> 1. Collaborate with Parks, WLRD, Roads, and other divisions interested in potential future projects on or near the parcel to understand barriers and opportunities.

Table 10. Burns Avenue Drainage Facility Adaptation Actions / Considerations.

Action Type	Potential Adaptation Actions / Considerations
No Regret	<ol style="list-style-type: none"> 1. Increase inspections and monitoring during high tide events to identify areas of erosion and sedimentation loading. 2. Collaborate with Parks, WLRD, Roads, and other divisions interested in potential future projects on or near the parcel to understand barriers and opportunities.
Low Regret	<ol style="list-style-type: none"> 1. Develop a draft scope for a future retrofit to the stream bypass in the event that sea level rise reduces the function of the assets. 2. Adding sea level rise considerations as a requirement of the Surface Water Design Manual's updated version to increase adaptive capacity. 3. Develop a plan to require stormwater capital improvement projects to complete an impact assessment if a project is in or near the sea level rise inundation zones.
Co-Benefit	<ol style="list-style-type: none"> 1. Collaborate with Parks, WLRD, Roads, and other divisions interested in potential future projects on or near the parcel to understand barriers and opportunities.

- Collaborate with Parks, WLRD, Roads, and other county agencies interested in potential future projects on or near both parcels to understand barriers and opportunities to increase resiliency to sea level rise.
- Determine the best approach for including sea level rise considerations in the next update of the King County SWDM.
- Determine the best approach for including sea level rise impact assessments into SWSS capital improvement project processes.
- Assess the cost, benefit, and outcomes of installing a flood gate to the Hamm Creek site outfall.
- Work with SWSS Capital Group to draft scopes for any effective future retrofits to both facility sites.

3.3.3 Wastewater Treatment Division (WTD)

3.3.3.1 Impacts Assessments: WTD

The King County Wastewater Treatment Division (WTD) provides regional wastewater services for approximately 1.9 million people, including most urban areas of King County and parts of south Snohomish County and northeast Pierce County. The system includes three large regional treatment plants (West Point in the City of Seattle, South Plant in the City of Renton, and Brightwater in south Snohomish County), two small treatment plants, one community septic system, five combined sewer overflow (CSO) treatment facilities in Seattle, over 350 miles of pipes, 25 regulator stations, 48 pump stations, and 39 CSO outfalls. WTD assets located in the mapped sea level rise exposure zones include two wastewater treatment plants, two wet weather treatment stations (WWTS), 18 pump and regulator stations, 20 pump and regulator stations, 380 maintenance holes and other minor structures, and over 52 miles of conveyance. The majority of the assets are located in the Lower Duwamish, West Seattle, and Elliott Bay vicinities (Figure 13).

Overall, in comparison to other agencies, WTD's risk of sea level rise is higher due to having more fixed assets within the mapped sea level rise zones in general and having a larger number of those assets mapped within the high exposure zone. Impact ratings were more likely to be high or medium due to the interconnected nature of the system or asset complexity, which can affect adaptive capacity.

Assessment results for large assets or major asset classes are summarized in Table 11. Assets were grouped given the large number of assets identified for assessment and the fact that assets of the same type typically experience similar sea level rise impacts, have similar sensitivities to those impacts, and have similar adaptive capacities. The two WWTPs are discussed separately due to distinct differences in the plants.

WTD sea level rise concerns fell into the following general categories:

- *Inundation*: Basic flooding of an asset site both on the surface of the site as well as internal to a facility. Inundation may be permanent or episodic depending on asset location.
- *Saltwater Intrusion*: Higher tides and storm surge events can cause saltwater intrusion into the conveyance system directly through outfalls or indirectly through other conveyance systems connected to the WTD system, including the City of Seattle sanitary and stormwater sewer systems and private connections. Relative to the potential for inundation, saltwater intrusion is considered a more damaging and urgent near-term sea level rise impact.

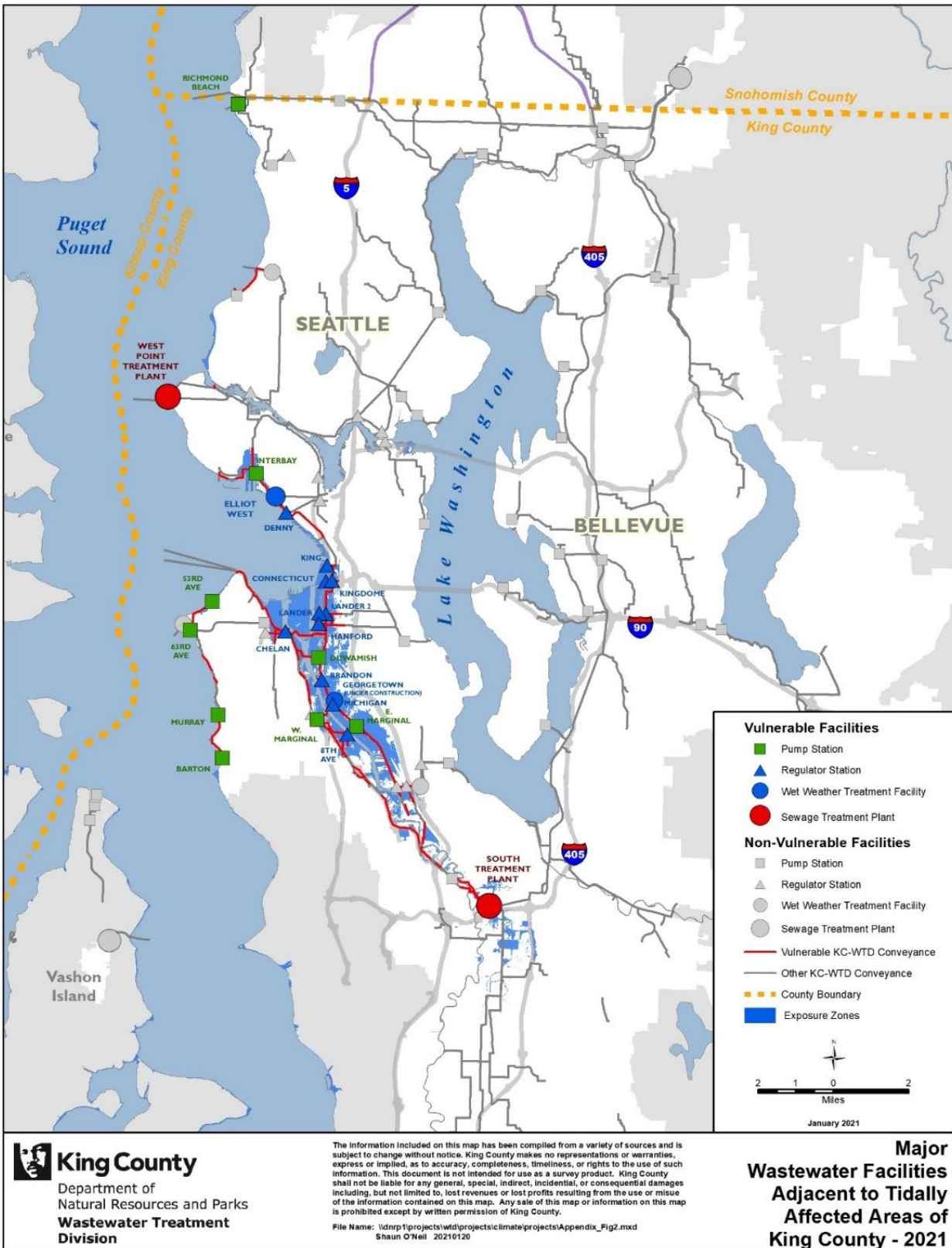


Figure 13. Vulnerable Wastewater Treatment Division Assets Map. Map shows major facilities adjacent to tidally affected areas of King County. *Image: KC WTD*

Table 11. Wastewater Treatment Division Asset Assessment Exposure Zone and Overall Impact Ratings.

Asset/Asset Class	General Description	Exposure Zone	Overall Impact Rating
West Point Wastewater Treatment Plant	The West Point plant is a major wastewater treatment facility that handles most of the wastewater flows from Seattle. The plant is located on 30 acres and is surrounded by a dual wall system that provides a visual and security barrier. Parts of the plant property are located in the mapped sea level rise exposure zones.	MEDIUM	HIGH
Pump Stations	Pump stations (PS) lift wastewater allowing it to flow into the gravity conveyance system. Eight pump stations are within the sea level rise exposure zones: 53rd Ave. SW PS, 63rd Ave. SW PS, Barton St. PS, E. Duwamish PS, East Marginal Way, Interbay PS, Murray Ave. PS and Richmond Beach PS.	HIGH	HIGH
Regulator Stations	Regulator stations (RS) control the direction of flow between interceptors conveying to the treatment plant and an overflow. During high flows, a RS will limit access to the interceptor allowing flows to overflow into a water body. Ten RS's are within the sea level rise exposure zones: 8th Ave. S., Brandon St., Chelan Ave., Denny Way, Hanford #2, King St., Kingdome/Connecticut St., Lander, W. Michigan St., and Lander St. Stormwater.	HIGH	MEDIUM
Conveyance Lines	Conveyance lines (pipes) collect water from cities and utility districts and move it to treatment plants. Pipes range from 2 inches to 14 feet in diameter. Conveyance lines under pressure from flow pump stations are referred to as force mains.	HIGH	MEDIUM
Wet Weather Treatment Stations	The Elliott West Wet Weather Treatment Station (WWTS) and the Georgetown WWTS are part of the combined sewer system and can be used for primary wastewater treatment during heavy rains when large volumes of water can overwhelm the system.	LOW	MEDIUM
South Wastewater Treatment Plant	The South Treatment Plant, located in Renton, is a secondary treatment facility treating wastewater from homes and businesses located east and south of Lake Washington.	LOW	LOW

Note: Exposure zone and overall impact rating options are high, medium, or low. A high impact rating means the asset is expected to be affected by sea level rise in ways that significantly impact use of the asset.

- *Hydraulic impacts:* Includes inflow through outfalls and overland as surcharged stormwater backed up due to high tides into the conveyance system. This additional flow reduces the ability to convey wastewater while increasing the need for additional power to pump effluent through higher head pressure at the outfalls. Hydraulic impacts are already an issue at facilities with outfalls and weirs designed for past (i.e., lower) water levels.
- *Groundwater dynamics:* As sea levels rise, the degree to which groundwater levels will be impacted is unknown. However, rising groundwater levels could impact the functionality of both vertical and horizontal assets by increasing infiltration leading to capacity reductions and internal flooding as well as undermining the stability of assets designed to operate on more stable soils.

- *Access limitations:* During high tide events, some assets may be cut off from direct access by staff because of impacts to transportation routes to the facility or other impacts affecting the asset.

The degree to which any of these impacts affects a specific asset will depend on asset location and type. More information on these impacts and assessment results for the assets in Table 11 are summarized in the sections below, as ordered in Table 11.

West Point Wastewater Treatment Plant

The West Point Wastewater Treatment Plant (West Point WWTP) occupies 30 acres on the tip of a peninsula that extends into Puget Sound from Seattle’s Magnolia neighborhood. The West Point WWTP treats most of the wastewater flows from Seattle. It is surrounded by a dual wall system constructed in 1994 which provides a visual and security barrier. Landscaped berms provide a barrier between the beach and the plant on the south side near the plant entrance (Figure 14).



Figure 14. Walls Around West Point WWTP After Construction in 1995. Photo: King County.

While the WWTP itself is not directly in an exposure zone, the overall asset was assigned to the **medium exposure zone** (Figure 15) due to the many underground areas within the WWTP, including the galleries, that sit below the tidal elevation of the Puget Sound. Additionally, while the plant is surrounded by a berm (Figure 14) that exceeds the height necessary to protect the WWTP from inundation well beyond 2100, the main entrance of the plant is below projected tide levels and is a point of concern. The sand dune southwest of the entrance, an asset under the responsibility of the City of Seattle, currently provides protection to the vulnerable low-lying entrance.

As per findings in *Vulnerability of the West Point Treatment Plant to Flooding from Sea-Level Rise* (KCWTD, 2013), this assessment finds that the West Point WWTP is not at risk of major inundation due to overtopping of the berms and walls from future sea level rise. The structures that protect the plant such as the walls and southern beach berms are important protection against future sea level rise. The

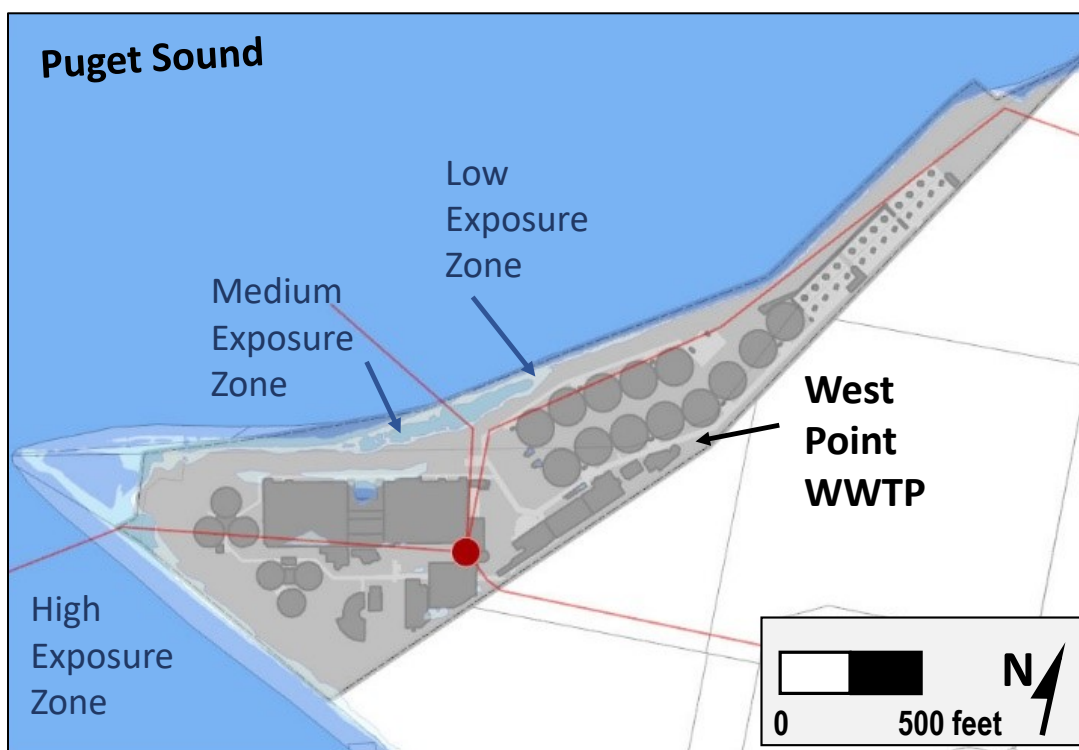


Figure 15. Sea Level Rise Exposure Zones at West Point WWTP. The WWTP is not mapped within a single exposure zone. However, Parts of the site are mapped in high exposure zones and indicate potential inundation and storm surge into lower inland elevations in the WWTP. Image: SLR and KCGIS (2018-2020).

low-lying main entrance could present a future entry point for tidal flooding if the sand dune protecting that entrance were to become compromised. Monitoring of the dune protecting the low-lying entrance will be needed to ensure ongoing protection.

Inundation is not the only impact of sea level rise that will need to be monitored, however. The direct connection of treatment plants like West Point to tidally influenced water bodies via overflow/outfall pipes increases exposure and sensitivity. Modeling and monitoring the hydraulic impacts of rising tides on the emergency bypass and main outfalls are necessary to fully understand and mitigate future vulnerabilities.

Treatment plants are large and complex capital facilities with sensitive mechanical and electrical components and no redundancy in their system function. Additionally, the West Point WWTP cannot be moved. While there are planned and ongoing efforts to reduce vulnerability, these are not complete and the facility's proximity to the shoreline, exposed both from the north and the southwest, means that sea level rise will remain an ongoing concern that must be monitored and accounted for as part of asset management. This combination of high sensitivity and low adaptive capacity were key factors the **high overall impact rating** for the West Point WWTP.

Pump Stations

Pump stations lift wastewater, allowing it to flow back into the gravity conveyance system. Eight pump stations are mapped in the sea level rise exposure zones: 53rd Ave. SW, 63rd Ave. SW, Barton St., E. Duwamish, East Marginal Way, Interbay, Murray Ave., and Richmond Beach. While exposure varies with

each pump station, WTD chose to assign the asset class as a whole a **high exposure** rating. Sea level rise has already been an issue for several pump stations, including the 63rd, 53rd, and Barton Pump Stations.

Primary sea level rise concerns include preventing saltwater overtopping weirs in pump stations (e.g. 63rd Pump Station), water tightness of exposed access points subject to high pressures of storm surge and inundation (e.g. 63rd Pump Station), erosion of seawalls maintained by other jurisdictions (e.g. 53rd Pump Station), and indirect saltwater intrusion through outfalls (e.g. Barton Pump Station) or from residential connections (e.g. Bunker Trail Pump Station). Other expected sea level rise impacts are access limitations and rising groundwater.

Pump stations have complex mechanical and electrical components, are located underground in low lying areas, and have no redundancy in their system function. These attributes make pump stations highly sensitive to the impacts of sea level rise. Additionally, the direct connection of a pump station to tidally influenced water bodies via an overflow pipe increases exposure and sensitivity. Because the costs for moving assets and the complexity of station mechanics are high and that these pump stations are vulnerable to all types of impacts, this asset class has a **high overall impact rating**.

Regulator Stations

Regulator stations are underground structures containing gates that control the direction of flow between interceptors conveying to the treatment plant and an overflow. During high flows, operators will close a gate limiting access to the interceptor and open a gate allowing the high flows to overflow into a water body. Some regulator stations do not have outfall gates but contain weirs allowing overflows to occur when flows reach a certain level. Ten regulator stations are located in the **high exposure zone**: 8th Ave. S., Brandon St., Chelan Ave., Denny Way, Hanford #2, King St., Kingdome/Connecticut St., Lander, W. Michigan St., and Lander St. Stormwater.

Primary sea level rise concerns at regulator stations include saltwater overtopping weirs at stations, high pressures of storm surge (hydraulic impacts) and inundation, erosion and subsequent undermining of sea walls (e.g. Denny Way), rising groundwater, and saltwater intrusion. The lowest major asset in the system is the 8th Ave Regulator Station, located on the Duwamish River. A failure of this asset in an area where groundwater is already a concern could impact service at residential homes and require coordination with other jurisdictions. Like pump stations, regulator stations are sensitive and complex assets. However, these assets have more adaptive capacity to mitigate impacts. This class of assets was therefore given a **medium overall impact rating**.

Conveyance Lines

Conveyance lines collect the wastewater flows from cities and water districts and move it to treatment plants for treatment and resource recycling. These pipelines can range from two inches to 14 feet in diameter. For the purposes of this assessment, all of the identified conveyance assets located in the mapped sea level rise exposure zones are considered to be in a **high exposure zone**.

Primary sea level rise concerns for conveyance include erosive forces (e.g. Barton Force Main seawall, North Beach Force Main), inundation (e.g. South Magnolia Interceptor), saltwater intrusion, and access limitations. Related changes in groundwater levels near the shoreline could also increase groundwater infiltration into conveyance lines. Even though these assets are underground and protected from many of the direct impacts of sea level rise, 1) impacts are multiple and cumulative on any one system, 2) these assets are not easily moved, and 3) relocating conveyance lines would be costly. Therefore, this class of assets is given a **medium overall impact rating** (Table 11).

Wet Weather Treatment Stations

Wet Weather Treatment Stations (WWTS) are complex facilities located in low lying areas that provide primary wastewater treatment for key parts of the combined sewer system during heavy rain events. These systems operate when there are large volumes of stormwater that would otherwise overwhelm the capacity of the treatment and/or conveyance system.

Two WWTS are located within the mapped sea level rise exposure zones: the Elliot West WWTS and the Georgetown WWTS (under construction). The Elliot West station is in the low exposure zones. The Georgetown WWTS had some areas in the medium exposure zone but these areas are in isolated locations away from the Duwamish River. For the purposes of this assessment, a **low exposure zone** rating was assigned to the WWTS asset class.

WWTS are moderately sensitive to the impacts of sea level rise. Potential impacts include erosion, flooding, hydraulic impacts, saltwater intrusion, and groundwater infiltration. The direct connection of a WWTS to tidally influenced water bodies via an overflow pipe can also lead to saltwater inflow into the facilities. While these are complex assets that cannot easily be moved to adapt, they are only used for a limited time during heavy precipitation events. As a result, these facilities have a **low overall impact rating**.

South Wastewater Treatment Plant

The South WWTP, located in Renton along the Duwamish River, is a secondary treatment facility that treats wastewater from homes and businesses coming from cities located east and south of Lake Washington. Approximately 90 million gallons a day (mgd) of wastewater is treated during the dry months and up to about 300 mgd flows can be treated during the wet season.

The South WWTP lies upstream of the tidally influenced portion of the Duwamish River and outside of the area of interest for this evaluation. However, there are small areas of the plant adjacent to the Black River (a tributary of the Duwamish) that fall into medium and low exposure zones from ponding. While direct exposure is not currently apparent, changes to how the Black and Duwamish Rivers respond to rising sea levels, as well as the criticality of the facility, warrant inclusion of the South WWTP on this list. A **low exposure zone** and **low overall impact rating** have been assigned to this facility at this time.

3.3.3.2 Adaptation Actions: WTD

WTD's adaptive capacity for addressing sea level rise impacts varies with individual assets and by asset category. Potential adaptation actions for addressing sea level rise impacts on WTD assets include a range of structural adaptations, partnerships, and programmatic strategies that will provide resiliency for WTD conveyance assets at a broader level. These actions build on more than a decade of ongoing research and action to reduce sea level rise impacts on WTD operations and infrastructure, including four WTD actions related to sea level rise preparedness in the 2020 SCAP (Table 12). Asset-specific and programmatic adaptation actions are summarized in the next sections.

Treatment Plants

Potential adaptation actions for the West Point WWTP include the following. These are in addition to 2020 SCAP actions noted at right in Table 12.

- *Ensure continued protection of the main entrance:* Monitor the sand dune protecting the southwest entrance to ensure ongoing protection. Reevaluate the dune at regular intervals and upon the acquisition of updated LiDAR or similar elevation data. Work with the City of Seattle to ensure maintenance of sand dune.
- *Maintain berm integrity:* Coordinate with the King County River and Floodplain Management Section to identify and monitor any additional indicators that the berm can no longer provide protection against coastal flooding and sea level rise.
- *Sea level rise modeling:* Support research on changes in coastal flooding via investment in the United States Geological Survey’s Coastal Storm Modeling System (CoSMoS) (now a 2020 SCAP action). Model sediment transport in the Puget Sound and identify possible impacts to the protective dune due to sea level rise-related changes in tidal elevations and waterbody dynamics.
- *Manage onsite flooding:* Install standpipes into existing sumps so that portable pumps can be utilized above impacted areas to evacuate the water from low lying areas in a safe and efficient manner.
- *Mitigate impacts on discharges:* Evaluate impacts on pump capacity to discharge to the Puget Sound with higher tidal and flooding pressures.

Table 12. WTD 2020 SCAP Actions Relevant to Preparing for Sea Level Rise.

- Develop guidance and recommendations to further incorporate climate change considerations within Wastewater Treatment Division programs, projects, and operations.
- Assess the hydraulic impacts of saltwater intrusion on WTD’s conveyance system and develop a strategy for addressing those impacts.
- Expand WTD’s assessment of how projected changes in rainfall intensity affect the wastewater system.
- Partner with the U.S. Geological Survey to aid in the development of the Puget Sound Coastal Storm Modeling System.

While no formal adaptation recommendations were made for the South Treatment Plant, it was suggested that the mapping results and the potential for sea level rise impacts on flooding along the Duwamish River be included in future flood planning for the South Plant. Additional recommendations for conveyance lines connected to the South Plant are noted in the *Conveyance Lines* section below.

Pump Stations/ Wet Weather Treatment Stations/ Regulator Stations

Efforts to adapt WTD pump stations to higher sea level are already underway at locations where seawater inflow has occurred (63rd, 53rd, and Barton Pump Stations). Steps taken have included installing flap gates, raising areas around door thresholds to prevent sea water from entering facilities (63rd Pump Station), and adding alternative emergency access (63rd Pump Station).

Many of the mechanical systems and climate impacts are similar at pump stations, wet weather treatment stations, and regulators stations. Additional potential actions relevant to this group of asset classes include the following:

- Retrofit existing pump stations to include waterproof doors, as needed based on exposure.

- Evaluate hatch covers, Bilco doors, and at-grade vents for water tightness. Seal as needed.
- Raise ventilation infrastructure above future high water levels.
- Raise thresholds at access points for more complex facilities to an elevation above future sea level rise projections.
- Evaluate installing knee-walls around penetrations into facilities or around the entire footprint of facilities.
- Install conductivity meters/sensors to identify saltwater entering the system.
- Where relevant, work with the City of Seattle to reduce erosion and ensure maintenance of nearby sea walls.
- Coordinate with the WSDOT regarding their approach to sea level rise and any changes to the ferry terminal that might impact the Barton Pump Station, co-located at the WSDOT Fauntleroy ferry terminal.

Conveyance Lines

Potential adaptation actions for conveyance lines include the following:

- Check water-tightness of maintenance hole, air inlets, and other potential access points for water.
- Evaluate the North Interceptor Bypass structure/outfall for removal or retirement. If kept, evaluate the weir elevation and the potential for inundation.
- Evaluate the South Magnolia Interceptor vent pipes for their necessity. If needed, develop a plan for how to maintain operability in light of possible inundation.
- Invest in research on sea level rise and groundwater dynamics in the Lower Duwamish flood plain, and how any changes will affect the cathodic protection of the Effluent Transfer System, which runs from South Plant along the Duwamish River to the Puget Sound at Duwamish Head.
- Check for backflow preventers on reclaimed water systems at the South Plant to reduce the potential for contamination if flooding occurs. Ensure that preventative maintenance tasks for backflow preventers are in the WTD Computerized Maintenance Management System and up to date.

Programmatic Actions

In addition to strategies developed to address impacts at individual locations, a suite of programmatic strategies was identified to help increase asset resilience more broadly. These strategies fall into four main objective categories. Many of these recommendations have already been incorporated into actions for the 2020 SCAP.

- *Preventative maintenance:* Preventative maintenance should include inspections, actions, and programs that minimize the risk of sea level rise to the system. Actions include inspecting flap gates and pressure sewers; sealing maintenance hole and other facility lids; and developing a saltwater intrusion program (currently under development).
- *Hydraulic evaluation:* A hydraulic evaluation was recommended to help identify where saltwater intrusion is possible, including where there are connections to other conveyance systems that might allow cross connection to sources of saltwater. Now a 2020 SCAP action, the hydraulic evaluation will also identify the scale of the impact(s) including time, frequency, geographic extent, and volume with a particular focus on impacts affecting the capacity and ability to shed overflows and effluent against higher head pressure. Another goal is developing thresholds to trigger timely adaptation actions such as changing weir heights or adding gates.

- *Information management:* WTD should continue to invest in research that reduces or eliminates key knowledge gaps related to sea level rise impacts, providing the information needed to make adaptation decisions more efficiently in the future. Strategies include:
 - Supporting research on changes in coastal flooding via investment in the United States Geological Survey's Coastal Storm Modeling System (CoSMoS) (a 2020 SCAP action planned for 2021-2024);
 - Studying the specific effects of rising sea on groundwater levels in locations that contain WTD assets (part of the CoSMoS SCAP action, planned for 2021-2024);
 - Providing guidance to WTD planners and designers (now part of the 2020 SCAP action to develop guidance and recommendations to further incorporate climate change considerations in WTD decision making processes; work underway); and
 - Staying current with sea level rise science and policy.

Including the information identified through efforts such as this assessment in WTD document management systems is also needed to help ensure that the information is retained, easily accessible, and usable.

- *Leveraging existing decision processes:* WTD has many tools already developed to plan and guide capital and operational decisions. This objective intends to leverage those existing processes to factor sea level rise into those decisions. Synergies identified to date include the Six Year CIP plan, the Project Management Checklist, Problem Definition, the Sustainability Scorecard, the Clean Water Plan, and the CSO Long Term Control Plan.

4. SUMMARY FINDINGS AND NEXT STEPS

The *Sea Level Rise Impacts on King County Assets* assessment represents an important step in preparing for sea level rise in King County government. By engaging a larger set of King County agencies, the assessment provided an opportunity to broaden the discussion about sea level rise preparedness and develop a more comprehensive understanding of sea level exposure, impacts, and adaptation measures for County assets. The assessment also highlighted the importance of coordinating adaptation efforts across programs for agency assets that are in close proximity to each other or otherwise linked (e.g., Roads/Stormwater Services; Parks/Roads).

This assessment found that **the risk of sea level rise is fairly limited overall for most King County agencies**. This is true both in terms of the overall number of assets located in the sea level rise exposure zones and the number of assets with a high overall impact rating. This does not mean that sea level rise can be ignored, however. Sea level rise is expected to affect a variety of existing assets and will need to be factored in the ongoing asset management. It is also critical that sea level rise be factored into siting, design, and operation considerations for new assets.

Summary findings are presented in two ways: assets with a high exposure to sea level rise and assets with a high overall impact rating. This approach allows us to view setting priorities for planning for sea level rise through two lenses:

- 1) Which King County-owned assets are an assumed adaptation priority because they are expected to experience sea level rise sooner, relative to other assets? (i.e., which assets are in the high exposure zone?)
- 2) Which assets are an assumed adaptation priority *independent of location within the exposure zones* due to expected impacts, limited or costly options for adaptation, or other factors? (i.e., which assets have a high overall impact rating?)

Exposure Findings:

Which King County-owned assets are an assumed adaptation priority because they are expected to experience sea level rise sooner, relative to other assets? (i.e., which assets are in the high exposure zone?)

Overall, the assessment found that King County **asset exposure** to sea level rise is limited for most Divisions (Table 13). This is true both in terms of the overall number of assets in the sea level rise exposure zones and the number of assets with a high overall impact rating. WTD and Parks are notable exceptions to this conclusion about asset exposure. More specifically:

- **WTD and Parks** had the most fixed assets within the mapped sea level rise zones, including the most within the high exposure zone, relative to other Divisions. By virtue of their proximity to the shoreline, these high exposure zone assets will experience sea level rise impacts sooner, barring adaptive measures that change the exposure rating (e.g., moving or discontinuing use the asset) or otherwise affect the ability of a higher sea level to reach the asset (e.g., elevating a structure, building or raising a sea wall). The need to actively prepare these assets for sea level rise impacts is notably different, however. WTD's high exposure assets are part of an inter-connected network of built assets that would be negatively affected by sea level rise. In contrast, with the exception of Dockton Park, shoreline Parks assets are separate natural areas

that can adapt physically and ecologically to sea level rise in ways that remain generally consistent with their intended function.

- A small portion of the **Roads** network on Vashon and Maury Island is located within the high exposure zone. Of particular note are the Vashon and Maury Island connector roads, which already experience periodic road closures during extreme tides and storm surge events.
- **FMD's** "Flour Mill" Properties on Harbor Island had several fixed assets within the mapped high exposure zone. Other parts of the site are in the moderate exposure zone. The County could experience significant revenue losses if site, vehicle, and rail access and use are impacted. The County has low adaptive capacity for implementing onsite actions but could consider programmatic actions that may reduce their financial risk and losses.
- **Metro's** Water Taxi was the only Metro asset located in the high exposure zone. The Water Taxi facilities have a low overall impact rating due to the way Water Taxi infrastructure is designed to accommodate changing tide levels and the ability to adapt gangways and other infrastructure as needed to higher water levels over time. Sea level rise will be an important consideration for future construction of any supporting fixed assets related to Water Taxi service.

Overall Impact Findings

Which assets are an assumed adaptation priority independent of location within the exposure zones due to expected impacts, limited or costly options for adaptation, or other factors? (i.e., which assets have a high overall impact rating?)

Five assets or asset classes were assigned a **high overall impact rating** by the asset owners (Table 14). This included assets or asset classes owned by WTD, Road Services, Parks, and KCIA.

- **WTD** assets with a high overall impact rating are pump stations and the West Point Wastewater Treatment Plant. Pump stations have complex mechanical and electrical components, are located underground in low lying areas, and have no redundancy in their system function, making adaptation of these sites costly. The high impact rating for West Point is driven by the asset's criticality and complexity. While a significant portion of the West Point plant sits *outside* of the mapped exposure zones altogether, there is high sensitivity to any potential for flooding on the site or in underground areas. Sea level rise will remain an ongoing issue that WTD will want to monitor and account for as part of asset management at that site.
- **KCIA** warranted a high overall impact rating despite a low/medium exposure rating due to the high value of the asset and the complex, interconnected onsite activities. KCIA has high adaptive capacity for many of the potential impacts, although higher groundwater levels and higher amounts of sea level rise could require more costly adjustments.
- The Vashon and Maury Island connector roads are the one **Roads** asset with a high overall impact rating. As noted previously, these roads already experience periodic road closures during extreme tides and storm surge events. The high overall impact rating reflects the lack of a detour around the connectors and the costly adaptive measures (e.g., raising road elevations, moving roads, or building causeways) that will be needed to address sea level impacts on the connector roads. Other high exposure zone road segments along Dockton Road and SW Quartermaster Drive will be affected by sea level rise to varying degrees but detours are available, limiting the overall impact on these segments relative to the connector roads.

- **Parks** has one asset – Dockton Park and Natural Area – that rated a high overall impact rating. The Park’s use as a multi-purpose recreation site is significantly impaired with 2 feet of sea level rise. Key concerns factoring into the high overall impact rating are physical impacts on built amenities and services, reduced public access, limits on relocating infrastructure with higher amounts of sea level rise, and the potential environmental impacts to sensitive herring populations. Adapting the site for sea level rise will require moving or elevating infrastructure, or downshifting supported recreation uses at this popular site.

Adaptive Action Overview

King County agencies identified a variety of potential actions for adapting to sea level rise. Actions generally included the following:

- Making structural modifications to existing infrastructure,
- Temporary relocation of services or increased use of other short-term coping strategies,
- Permanent relocation of infrastructure or services,
- Increasing inspection and/or monitoring of conditions,
- Conducting additional studies to address key information gaps,
- Increasing connection and collaboration with local and regional partners on issues related to sea level rise,
- Incorporating sea level rise considerations into decision making processes, policy, and capital planning/asset management, and
- Letting natural assets adapt to sea level rise as it occurs.

Determining when, where, and which adaptive actions to implement will depend on the specific nature of the assets affected, how quickly sea level rises, and the cost of adaptative measures, among other factors. In all cases, it will be important that King County agencies periodically revisit and update the results of this assessment to reflect changes in sea level rise science, operations, facilities, and other factors that may influence exposure and sensitivity to sea level rise. Accounting for sea level rise in the location, design, and operation of existing and future assets near the shoreline will also be critical.

King County’s commitment to preparing for sea level rise also continues in the [2020 SCAP](#). The 2020 SCAP includes multiple actions that will benefit or otherwise help shape King County agency efforts to prepare for sea level rise. This includes:

- incorporating sea level rise into capital planning (Prep. 1.1.1),
- developing shared climate resources and projections to guide planning (Prep. 2.1.1 and Prep 2.1.2),
- working with the U.S. Geological Survey to model projected changes in the magnitude, frequency, and timing of coastal flooding along the King County shoreline (Prep 2.2.4),
- strengthening sea level rise planning partnerships in the lower Duwamish (Prep 4.2.1), and
- increasing public engagement on Vashon-Maury Island related to sea level rise (Prep 5.1.2).

Progress on these actions will be reported biennially in accordance with County requirements for SCAP reporting.

Table 13. Assets Identified with a High Exposure Rating. Results are generally ordered from higher to lower overall impacts rating while still being grouped by asset class owner.

Asset Class Owner	Asset or Asset Class with HIGH Exposure Ratings	Exposure Rating	Overall Impact Rating	Additional Notes
Wastewater Treatment Division (DNRP)	Pump Stations (8 stations)	HIGH	HIGH	Primary sea level rise concerns include preventing saltwater overtopping weirs in pump stations, water tightness of openings subject to high pressures of storm surge (hydraulic impacts) and inundation, erosion of seawalls maintained by other jurisdictions, and indirect saltwater intrusion through outfalls or from residential connections. Other expected sea level rise impacts are access limitations and rising groundwater. Pump stations have complex mechanical and electrical components, are located underground in low lying areas, and have no redundancy in their system function. Additionally, the direct connection of a pump station to tidally influenced water bodies via an overflow pipe increases exposure and sensitivity.
	Regulator Stations (10 stations)	HIGH	MEDIUM	These stations are located in the high exposure zone. Primary sea level rise concerns include saltwater overtopping weirs at stations, high pressures of storm surge and inundation, erosion and subsequent undermining of sea walls, rising groundwater, and saltwater intrusion. Regulator stations are sensitive and complex assets. However, these assets have more adaptive capacity to mitigate impacts than similarly situated pump stations.
	Conveyance Lines	HIGH	MEDIUM	All of the identified conveyance assets located in the mapped sea level rise exposure zones are considered to be in a high exposure zone. Primary sea level rise concerns erosive forces, inundation, saltwater intrusion, and access limitations. Adaptive capacity is limited by the fact that impacts are multiple and cumulative on any one system, the assets are not easily moved, and relocating conveyance lines would be costly.
Road Services Division (DLS)	Vashon and Maury Islands connector roads only	HIGH	HIGH	A small portion of approximately 2.5 miles of shoreline arterial and local road segments on Vashon and Maury Islands are mapped within the high exposure zone. Less than ½ mile of impacted shoreline road segments are located on Dockton Road and SW Quartermaster Drive, two higher volume arterials. All road segments likely to be exposed to rising sea levels have detours available, with the exception of the connections between Vashon and Maury Island.
Parks Division (DNRP)	Dockton Park and Natural Area, Maury Island*	HIGH	HIGH	Dockton Park experiences flooding in the parking lot and southwestern part of the property during King Tides and storm surge events, as well as overtopping of the bulkhead. The use as a multi-purpose recreation site is significantly impaired with 2 feet of sea level rise. Key concerns are impacts on built amenities and services, reduced public access, limits on relocating infrastructure with higher amounts of sea level rise, and the potential environmental impacts to sensitive herring populations. Large parts of Dockton Natural Area will experience increased tidal flooding and permanent inundation with 2 and 5 feet of sea level rise. Impacts on habitat quality and its continued role as an important herring spawning site are unknown. Any future decisions related to adapting Dockton Park and Dockton Road may positively or negatively affect the adaptive capacity of this area.

Table 13. Assets Identified with a High Exposure Rating (continued)

Asset Class Owner	Asset or Asset Class with HIGH Exposure Ratings	Exposure Rating	Overall Impact Rating	Additional Notes
Parks Division (DNRP) (continued)	Ellis Creek Natural Area , Vashon Island	HIGH	MEDIUM	Nearshore areas at this asset will be inundated as sea level rises and passive recreation will be somewhat impaired. While there is room for the habitat to move landward and adapt, that ability is potentially limited by the adjoining source water springs for Water District 19.
	Forest Glen Natural Area , Vashon Island	HIGH	MEDIUM	The shoreline portion of this area will see increased tidal flooding and inundation with 2 and 5 feet of sea level rise. King County-owned armoring that protects adjoining properties and infrastructure will need to be monitored and maintained.
	Raabs Lagoon , Quartermaster Harbor	HIGH	MEDIUM	The main concerns at this asset are the current overtopping of the bulkhead during King Tides, slide/erosion problems along high bank areas that can affect private property, and inundation of large portions of the site at 2 and 5 feet of sea level rise. The future of the aging bulkhead is uncertain and likely to be a political challenge.
	Bluff Back Natural Areas (8 sites); Spring Beach Natural Area ; and Maury Island Marine Park , Vashon Island	HIGH	LOW	These assets were acquired or otherwise designated for habitat preservation and passive recreation. The intent is to let sea level rise and nature takes its course.
Facilities Management Division (FMD / DES)	“Flour Mill” Properties , Harbor Island, Seattle	MEDIUM / HIGH	MEDIUM	Majority of this asset is currently managed through a five-year lease with Raymont Industries. The main concern is inundation blocking access and interrupting use of the site resulting in loss of lease revenue if the site is rendered less commercially useable. Additional concerns are a nonfunctional backflow valve from a stormwater treatment facility that allows seawater to flow toward the facility during high tides and the potential for some of the onsite materials to become mobilized and impact nearby parcels or present environmental hazards if allowed to enter the Duwamish River. Repairs are intended for the backflow valve in mid-year 2021. The more likely adaptive strategy for the properties would be to do little or nothing to improve the site and “absorb” the reduced revenues resulting from less critical uses or the cost of future tenants’ protective efforts through lower rents.
Marine Division (Metro)	Water Taxi Ferry Service , downtown Seattle, West Seattle, Vashon Island	HIGH	LOW	The Water Taxi passenger ferry terminal docks are located on the shoreline out of necessity, placing these facilities in the high exposure zone. The facilities have a low overall impact rating, however, due in part to the way Water Taxi infrastructure is designed to accommodate changing tide levels and the ability to adapt gangways and other infrastructure as needed to higher water levels over time.

Note: *Dockton Natural Area as a natural area would have an overall lower impact rating. Because Parks manages Dockton Natural Area and Dockton Park as an integrated asset, the overall rating is high.

Table 14. Assets Identified with a High Overall Impact Rating. Results are ordered based on asset criticality, complexity of operations on the site(s), and potential costs for adapting the assets while still being grouped by asset class owner.

Asset Class Owner	Asset or Asset Class with HIGH Overall Impact Rating	Exposure Rating	Overall Impact Rating	Basis for High <u>Overall Impact</u> Rating
Wastewater Treatment Division (DNRP)	West Point Wastewater Treatment Plant	MEDIUM	HIGH	<p>This is a critical asset that treats most of the wastewater flows from Seattle. While the plant itself is not directly in an exposure zone, the plant has many underground areas that sit below the tidal elevation of the Puget Sound. Additionally, while the plant is protected by a high berm, the main entrance of the plant is below projected tide levels.</p> <p>The high impact rating for the West Point plant is based on the facility’s high sensitivity to <i>any</i> potential for flooding, the high operational and economic value of the asset, and the inability to relocate the plant. The West Point WWTP is <i>not</i> at risk of major inundation due to overtopping of the berms and walls; the berm’s height is sufficient to protect the plant from inundation well beyond 2100. However, the low-lying main entrance could present a future entry point for tidal flooding if the sand dune protecting that entrance were to become compromised. The direct connection to Puget Sound via an overflow pipe also increases exposure and sensitivity.</p> <p>While there are planned and ongoing efforts to reduce vulnerability, the facility’s proximity to the shoreline means that sea level rise will remain an ongoing issue that WTD will need to monitor and account for as part of asset management at that site.</p>
	Pump Stations (8 stations)			HIGH

Table 14. Assets Identified with a High Overall Impact Rating (continued)

Asset Class Owner	Asset or Asset Class with HIGH Overall Impact Rating	Exposure Rating	Overall Impact Rating	Basis for High <u>Overall Impact Rating</u>
King County Internation'l Airport (DES)	North, Central and South Central Basin, Duwamish Valley	LOW / MEDIUM	HIGH	<p>The potential for sea level rise to affect the airport is very low due to its location in the lower Duwamish Valley. The high value of the asset and complex, interconnected onsite activities warranted a high impact rating, however.</p> <p>Sea level rise could affect the airport via three pathways: 1) overtopping of the Duwamish River shoreline and overland flow on the airport (associated with 5 feet of sea level rise and a 1% annual change surge event); 2) backflow of higher river levels onto the airport grounds via the stormwater outfall system (could happen with lower amounts of sea level rise); and 3) higher groundwater levels due to the combined effects of sea level rise on river levels and projected increases in winter rainfall.</p> <p>The airport has high adaptive capacity for the range of sea level rise considered in this assessment, although impacts associated with higher groundwater levels and higher amounts of sea level rise could require more costly adjustments.</p>
Road Services Division (DLS)	Vashon and Maury Islands connector roads only	HIGH	HIGH	<p>The rating is high given current King Tide/storm surge impacts on low-lying portions of Dockton and SW Quartermaster roads, specifically in the vicinity of the isthmus that connects Vashon and Maury Islands, the potentially high costs of addressing these sea level rise impacts, and that there is no road detour option for these short segments.</p> <p>More significant adaptive measures (e.g., raising road elevations, moving roads, or building causeways) are not an option at this time. Vulnerable road segments, such as those projected to be impacted by sea level rise, will continue to be closely monitored for safety and lane restricted or temporarily closed as needed until emergency repairs are completed.</p>
Parks Division (DNRP)	Dockton Park and Natural Area*, Maury Island	HIGH	HIGH	<p>Dockton Park's use as a multi-purpose recreation site is significantly impaired with 2 feet of sea level rise, resulting in a high overall impact rating for the site. Key concerns are impacts on built amenities and services, reduced public access, and limits on relocating infrastructure with higher amounts of sea level rise. The park already experiences flooding in the parking lot and overtopping of the bulkhead during King Tides and storm surge events. Areas along the southwestern part of the property also experience tidal flooding.</p> <p>Large parts of Dockton Natural Area will experience increased tidal flooding and permanent inundation with 2 and 5 feet of sea level rise. Habitat in the low-lying estuary has limited space to move back and will be permanently inundated with 5 feet of sea level rise. Impacts on habitat quality and its continued role as an important herring spawning site are unknown.</p> <p>Adapting the site for sea level rise will require moving or elevating infrastructure, or downshifting supported recreation uses at this popular site.</p>

Note: *Dockton Natural Area as a natural area would have an overall lower impact rating. Because Parks manages Dockton Natural Area and Dockton Park as an integrated asset, the overall rating is high.

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