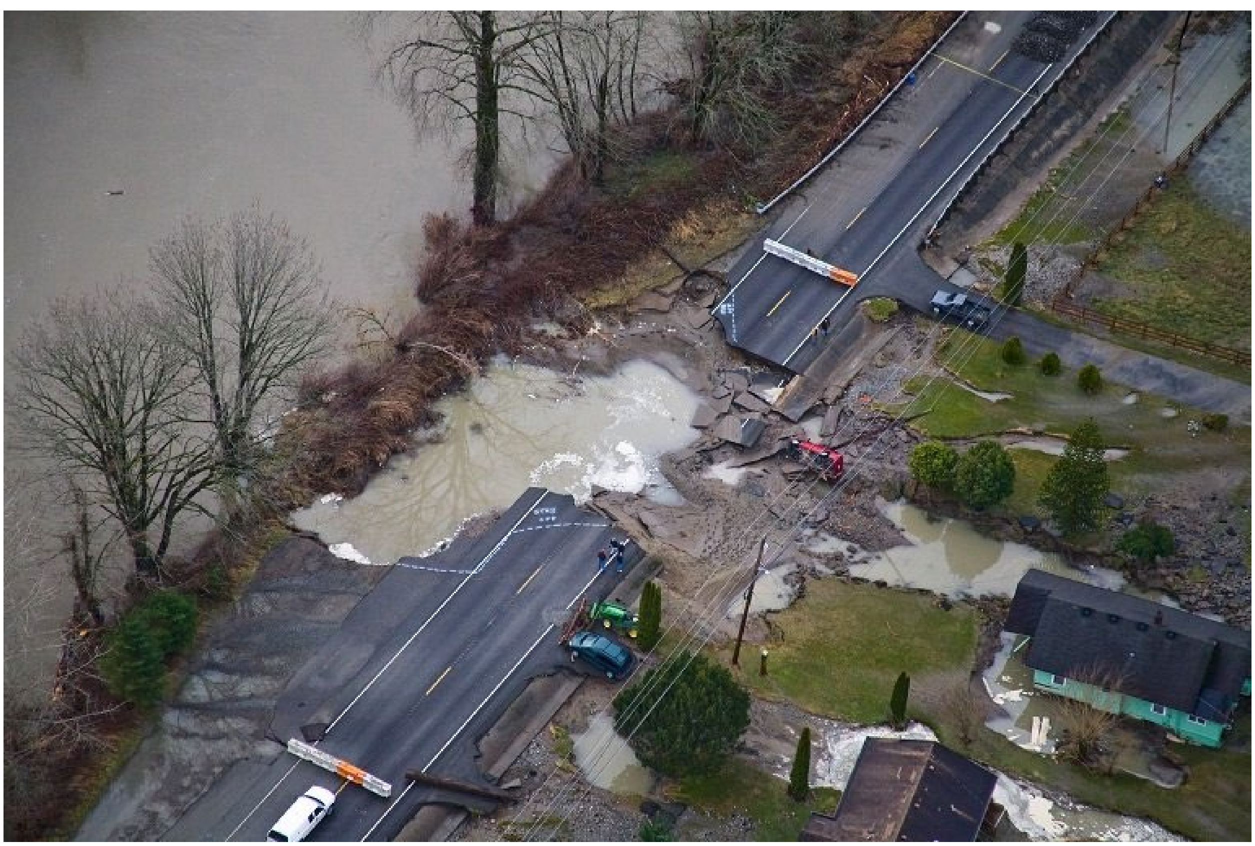
2024 KING COUNTY FLOOD MANAGEMENT PLAN

Draft

Prepared for
King County Water and Land Resources Division

January 2024



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King County Water and Land Resources Division
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EXECUTIVE SUMMARY

Flooding is the costliest and most frequent natural disaster in King County. The effects of flooding and flood-related hazards affect residences, commercial and industrial properties, farms, parks, and open space. Floods affect small neighborhood access roads and major highways, and they impact property owners and renters alike. Due to climate change, King County now experiences flooding in places that have not historically flooded.

While flooding can produce negative consequences and threaten public safety and property, flooding itself is a natural occurrence. In areas where floodplains and watercourses remain connected or have been reconnected, periodic floods help to create and maintain channel networks, floodplain wetlands, and vital and productive habitats. These habitats provide benefit to salmonids, such as Puget Sound Chinook salmon, which are central to the cultures and identities of Native American tribes and are listed as threatened under the Endangered Species Act.

It is not possible to entirely prevent flooding, but it is possible to greatly reduce flood risks to people and property. This 2024 King County Flood Management Plan (Flood Plan) seeks to establish a shared regional vision for comprehensive flood hazard management in King County that reduces risk to people and property from flooding and channel migration and supports resilient communities and ecosystems. The Flood Plan identifies strategies for addressing the risks caused by flooding along the county's rivers and streams, in coastal areas, and in urban areas. The recommended policies, programs, and projects focus on reducing risk in ways that protect public safety while also elevating other beneficial outcomes, such as safe and accessible transportation routes, protecting and restoring natural habitat, preserving green spaces, and supporting jobs and the economy.

King County developed the Flood Plan with three primary themes at the forefront of the planning effort: laying the groundwork for achieving **multi-benefit outcomes**, promoting **climate resilience**, and ensuring that flood risk reduction activities are developed and implemented with a focus on **equity and social justice**. King County consulted with tribal governments during the planning process to gather their input on tribal rights and tribal resources. Community members and partners also informed the development of this plan, and the input shared with King County is reflected throughout this plan and informed the plan's approaches and recommendations.

The goals for this Flood Plan—the vision for what the plan hopes to achieve—are:

1. To reduce risks from flooding and channel migration and support resilient, viable communities and economies.

2. To achieve multi-benefit flood risk reduction outcomes that preserve, restore, and enhance the natural functions of flood-prone areas; improve floodwater storage and conveyance; contribute to habitat restoration; honor tribal sovereign rights, including treaty-reserved fishing, hunting, and gathering rights; and meet other needs identified by local communities.
3. To implement flood risk reduction solutions that are comprehensive, community-based, and climate-resilient, and that reduce long-term costs of flood risk reduction.

The 2024 Flood Plan reflects the reality that multiple governments and community partners are necessary to achieve flood risk reduction on a large scale, and the flood risk reduction activities identified in this plan are intended to promote coordinated implementation of activities that will reduce flood risk and provide other beneficial outcomes on a countywide scale. By recommending holistic solutions that address the range of flood-related hazards in King County, this Flood Plan will lay the foundation for equitable, climate-resilient, multi-benefit flood risk reduction and provide near-term guidance to King County and its partners.

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2024 King County Flood Management Plan

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Appendices (Separate Volume)

ACRONYMS AND OTHER ABBREVIATIONS

Acronym or Abbreviation	Definition
ADAP	Agricultural Drainage Assistance Program
APD	Agriculture Production District
BAS	Best Available Science
BIPOC	black, indigenous, people of color
BMPs	Best Management Practices
BRIC	Building Resilient Infrastructure and Communities Grant Program
cfs	cubic feet per second
CFT	Conservation Futures Tax
CIP	Capital Improvement Plan
Corps	U.S. Army Corps of Engineers
CoSMoS	Coastal Storm Modeling System
CRS	Community Rating System
CRT	Cedar River Trail
CWHH	Clean Water Healthy Habitat
DNRP	Department of Natural Resources and Parks
DS	Determination of Significance
Ecology	Washington Department of Ecology
EIS	Environmental Impact Statement
ELST	East Lake Sammamish Trail
EOC	Emergency Operations Center
ESA	Endangered Species Act
FCD	Flood Control District
FEMA	Federal Emergency Management Agency
FMA	Flood Mitigation Assistance Grant Program
GIS	geographic information system
GMA	Growth Management Act
GSI	green stormwater infrastructure
HMA	Hazard Mitigation Assistance Grant Program
HPPD	High Hazard Potential Dam Grant Program
I-90	Interstate 90

Acronym or Abbreviation	Definition
IDP	Integrated Drainage Program
IPCC	Intergovernmental Panel on Climate Change
ISO	Insurance Services Office
LCI	Land Conservation Initiative
LiDAR	Light Detection and Ranging
LWD	large woody debris
MHHW	mean higher high water
NDAP	Neighborhood Drainage Assistance Program
NDF	Natural Drainage Flooding
NFIP	National Flood Insurance Program
NGO	non-government organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
OEM	Office of Emergency Management
PL	Public Law
PPI	Program for Public Information
PSCZ	Puget Sound Convergence Zone
PWR LIO	Puyallup-White River Local Integrating Organization
RCW	Revised Code of Washington
SCAP	Strategic Climate Action Plan
SEPA	State Environmental Policy Act
SMP	Site Management Program
SODO	South of Downtown
SPU	Seattle Public Utilities
SRIP	Sammamish River Improvement Project
SRT	Sammamish River Trail
SVI	Social Vulnerability Index
SWIF	System Wide Improvement Framework
SWM	King County Surface Water Management
SWMP Plan	Stormwater Management Program Plan
TMDL	Total Maximum Daily Load
TPU	Tacoma Public Utilities

Acronym or Abbreviation	Definition
UGA	Urban Growth Area
USGS	U.S. Geological Survey
UW CIG	University of Washington Climate Impacts Group
WAC	Washington Administrative Code
WCM	Water Control Manual
WDFW	Washington Department of Fish and Wildlife
WLRD	King County Water and Land Resources Division
WRF	Weather Research and Forecasting
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WSRT	West Sammamish River Trail
WY	Water Year

GLOSSARY

Term	Definition
Alluvial	Characterized by or referring to deposits of clay, silt, sand, and gravel left by flowing streams in a river valley or delta, typically producing fertile soil.
Alluvial fan	A fan-shaped mass of alluvium deposited as the flow of a river decreases in velocity.
Alpine glaciation	A glacier that is confined by surrounding mountain terrain.
Avulsion	A sudden change in the course of a river, especially by flooding.
Base flood	A flood having a 1 percent chance of being equaled or exceeded in any given year, which is often referred to as the "1 percent annual chance flood" or "100-year flood."
Basin (or subbasin)	A geographic area that drains to a stream or a non-flowing waterbody (such as a named lake or marine area) named and noted on common maps.
Bioengineering	The use of vegetation and other natural materials, such as soil, wood, and rock to stabilize soil, typically to prevent or protect against slides and streamflow erosion.
Channel migration	The movement of a river or stream channel across a landscape through erosion, which can happen gradually over time or abruptly. Both gradual and abrupt migration present risks, and abrupt migration, called an avulsion, can pose especially dangerous risks to people and property.
Channel migration zone	The area within the lateral extent of likely stream channel movement that is subject to risk due to stream bank destabilization, rapid stream incision, stream bank erosion, and shifts in the location of stream channels, as shown on King County's Channel Migration Zone maps.
Climate change	A change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of solar cycles, volcanic eruptions, and persistent anthropogenic (human-caused) changes in the composition of the atmosphere or in land use.
Community Rating System (CRS)	Voluntary program under the National Flood Insurance Program (NFIP) that provides incentives to participating communities to implement activities that exceed the minimum requirements of the NFIP.

Term	Definition
Compensatory storage	New, excavated storage volume equivalent to any flood storage that is eliminated by building, filling, or grading within a floodplain. For this definition, equivalent flood storage capacity is that which is replaced by equal volume between corresponding 1-foot contour intervals, which are hydraulically connected to the floodway through their entire depth.
Confluence	The junction of two rivers.
Conifers	Evergreen trees, such as Douglas fir and western hemlock.
Convective storms and flooding	Convective storms involve heavy rainfall, thunder, lightning, and/or hail and are often spatially small, intense, and quick moving. Convective storms can contribute to flooding in small basins and in areas where urban stormwater systems can be overwhelmed.
Critical facility	A facility deemed necessary to protect the public health, safety, and welfare.
Equity	As defined by King County's Equity and Social Justice Strategic Plan, is the full and equal access to opportunities, power, and resources so that all people achieve their full potential and thrive.
"Flashy" hydrology	Refers to floodwaters that rise quickly with minimal infiltration, which results in higher, shorter duration floods than prior to urban development.
Flood protection facility	A structure that safeguards against flood damage. Flood protection facilities include, but are not limited to, dams or water diversions; flood containment facilities such as levees, dikes, berms, walls, and raised banks, including pump stations and other supporting structures; and bank stabilization structures, often called revetments.
Flood resilience	The ability to prepare for, respond to, and recover from flooding, thus reducing vulnerability to flooding so that future impacts are reduced.
Flood risk reduction	Any work intended to reduce the impact of hazards to people, property, and infrastructure associated with flooding. Human intervention cannot eliminate flooding, but humans can take measures to reduce the risks that result when flooding occurs.
Flooding	A general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of inland or tidal waters or the unusual and rapid accumulation of runoff of surface waters from any source. For the purposes of this Flood Plan, flooding could be caused by rivers or streams, surface water runoff, tides or wave action, or blockage of a pathway of flowing water due to landslides or erosion.

Term	Definition
Floodplain	Defined by FEMA as any land area susceptible to being inundated by floodwaters.
Floodplain management	Defined by FEMA as a community-based effort to reduce the risk of flooding and improve community resilience.
Hazard	An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, and other types of loss or harm.
Integrated floodplain management	As described by Ecology (2021), involves bringing together multiple interests to find common agreement on local floodplain visions, strategies, and actions that achieve multiple benefits.
Levee	A manmade structure, usually an earthen embankment, designed and constructed to contain, control, or divert the flow of water to provide protection from temporary flooding.
Moraine	A mass of rocks and sediment carried down and deposited by a glacier, typically as ridges at its edges or extremity.
Multi-benefit (or multiple benefits)	The suite of outcomes that can be achieved through efforts to reduce flood risk, such as enhancing habitat for fish and wildlife, increasing resilience to climate change, providing open space and recreational opportunities, supporting viable agriculture and commerce, and meeting the needs of local communities.
National Flood Insurance Program (NFIP)	The federal program under which flood-prone areas are identified and flood insurance is made available to the owners of the property in participating communities.
Outburst flooding	Catastrophic flooding caused by the sudden release of a large amount of water (such as in a dam break).
Pluvial	Relating to or characterized by rainfall.
Redd	Refers to the spawning bed (nest) of salmon or trout in a river or stream.
Repetitive loss property	Any NFIP-insured property that, since 1978 and regardless of any change of ownership during that period, has experienced any of the following: four or more paid flood losses exceeding $1,000 each; two paid flood losses exceeding $1,000 each within any 10-year period since 1978; or three or more paid losses that equal or exceed the current value of the insured property.
Revetment	A facing of stone, rock, or other material placed on a stream bank or slope to minimize erosion by moving water.
Risk	The estimated impact that a hazard could have on people, services, facilities, and structures in a community.

Term	Definition
Shoreline armoring	Lining perimeters of rivers, streams, lakes, or marine areas with rock or concrete to stabilize the shoreline and prevent erosion or channel migration.
Sinuosity	Refers to the degree of meandering within a river channel, defined as the ratio of stream length to valley length. More simply, it is the amount of curvature of a river.
Swale	A shallow channel with sloping sides. Swales can be either natural or human-made. Artificial swales are often designed to manage stormwater runoff.
Water Resource Inventory Areas (WRIAs)	Formalized under Washington Administrative Code (WAC) 173-500-040[1] and authorized under the Water Resources Act of 1971, Revised Code of Washington (RCW) 90.54,[2] these administrative and planning areas are delineated by major river watersheds.
Watershed	An area of land that drains into a single outlet and is separated from other drainage basins by a divide.

1 Water Resource Inventory Areas; https://app.leg.wa.gov/wac/default.aspx?cite=173-500-040.

2 Water Resources Act of 1971; https://app.leg.wa.gov/rcw/default.aspx?cite=90.54.

CHAPTER 1
Introduction

White River Countyline Floodplain Reconnection project, September 2023

Flooding is the costliest and most frequent natural disaster in King County. Since 1990, King County has experienced 15 presidentially declared flooding disasters resulting in millions of dollars of property damage. Smaller floods are no less significant for those who are affected by them. More than 50,000 people live in King County's mapped flood hazard areas, and many thousands more people work and travel through areas subject to flooding. Over the course of 30 years, the length of a typical home mortgage, someone living in the 1 percent annual chance floodplain (also referred to as the 100-year floodplain) faces a 26 percent chance of experiencing flooding.

Flooding affects residences, commercial and industrial properties, farms, parks, and open space. It affects small neighborhood access roads and major highways, and it impacts property owners and renters alike. Due to climate change, King County now experiences flooding in places that have not historically flooded. Flood events are a natural occurrence that cannot be prevented, but it is possible to greatly reduce flood risks to people and property.

King County has had active flood risk reduction programs for decades. Since the 1990s, the County's policies and programs have focused on preventing new at-risk development in flood and erosion hazard areas through development regulations. Recognizing that rivers are dynamic, and that the location and extent of flood-related hazards can change over time (and in some cases rapidly), King County was one of the first local governments in Washington to map and regulate channel migration hazards. The County also made early use of federal grants to acquire flood-prone property in order to remove risk to people and structures in areas subject to flooding and channel migration.

More recently, the County and partners have successfully designed and implemented projects along the county's waterways that reduce the risk of flooding while providing additional benefits. These benefits include improving habitat for salmon, improving or expanding open space and recreational access, improving water quality, protecting and ensuring agricultural viability, supporting economic development and transportation, and improving the overall quality of life for county residents.

The purpose of this 2024 King County Flood Management Plan (Flood Plan) is to establish a shared regional vision for comprehensive flood hazard management in King County that reduces risk to people and property from flooding and channel migration and supports resilient communities and ecosystems. The Flood Plan brings multi-benefit approaches, climate change, and equity to the forefront of flood risk reduction in King County and promotes solutions that preserve, restore, and enhance the natural functions of flood-prone areas wherever possible.

Given the geography of King County, which extends from the Cascade Mountains to Puget Sound, flooding takes several forms and has numerous interrelated causes. Likewise, the solutions to reduce risks from flood-related hazards should be multifaceted and recognize the possibilities for achieving multiple benefits for county residents in ways that are effective and efficient. The Flood Plan addresses flooding along the county's mainstem rivers as well as coastal flood hazards, lake flooding, urban flooding, and tributary flooding. In addition to describing types of flooding and flood-related risks, the Flood Plan recommends policies, programs, and projects focused on reducing risk and increasing community resilience to floods, and the plan is intended to guide all county agencies that work at the intersection of flooding.

This plan was informed by an extensive community outreach and engagement effort. County staff attended community events and meetings, visited immigrant farming operations, hosted online surveys, partnered with a community-based organization, convened a planning committee of partners and community members, held public meetings and workshops, and used various types of media to advertise and promote opportunities to contribute input to the development of this plan. The input shared, and the ways the input informs this plan's approaches and recommendations, are presented throughout the plan.

The 2024 Flood Plan updates and supersedes the 2006 King County Flood Hazard Management Plan and the 2013 King County Flood Hazard Management Plan Update and

Progress Report. Like those previous plans, this Flood Plan was developed following the Federal Emergency Management Agency's (FEMA) Community Rating System (CRS) 10-step planning process. In addition to advancing the goals of the National Flood Insurance Program (NFIP), the Flood Plan is consistent with the Revised Code of Washington (RCW) Chapter 86.12.200[1] and was further guided by the principles outlined in the Washington Department of Ecology's (Ecology) *Comprehensive Planning for Flood Hazard Management: A Guidebook* (Ecology 2021)[2]. Moreover, King County's obligation under the Endangered Species Act (ESA)—and specifically, to restore habitat for salmon listed as threatened under the ESA—was a primary planning consideration, alongside other King County initiatives related to equity and social justice, climate change, local food production, and clean water and healthy habitat.

1.1 Roadmap for this Flood Plan

Flooding is a complicated problem with many intersecting causes and solutions, and flooding characteristics can differ dramatically depending on location. This Flood Plan attempts to present these complex topics simply. The Flood Plan examines flooding throughout King County, yet the nature of flooding and drainage issues are extensive, and this Flood Plan does not address every flooding situation across the entire landscape. Instead, the Flood Plan characterizes the different types of flood hazards and flood problems across the county and details various strategies to address identified problems to improve the resilience of county communities.

The Flood Plan is structured as follows:

- **Chapter 1 - Introduction** (this chapter)
  - Plan purpose, themes, and geographic scope, including identification of new topics and focus areas for this Flood Plan.
  - Goals, objectives, and guiding principles that provide the vision for flood risk reduction in King County.
  - Policies that guide decision-making around flood risk reduction activities, including flood hazard management planning, programs, and projects.
  - Overview of the planning process.
  - Summary of the State Environmental Policy Act (SEPA) review process.
  - Regulatory drivers and other factors and initiatives that influence or relate to the Flood Plan.
- **Chapter 2 – Overview of Flooding in King County**
  - Countywide context.
  - Summary of existing conditions, flooding characteristics and risks, and additional information about flooding, presented by geography (i.e., watershed).

1 https://app.leg.wa.gov/RCW/default.aspx?cite=86.12.200.

2 https://apps.ecology.wa.gov/publications/documents/2106019.pdf.

  - Summary of countywide flood hazard and risk assessment.
- **Chapter 3 – Review of Flood Risk Reduction Activities**
  - Discussion of the range of options that could be used to prevent or reduce the severity of the flooding problems identified in Chapter 2.
- **Chapter 4 – Comprehensive Risk Mitigation Strategy and Action Plan**
  - Comprehensive review of the various projects and programs that can be used to address flood risk, including King County's Action Plan.
- **Chapter 5 –Implementation Plan**
  - Summary of financial approaches and partnerships to achieve the goals of this Flood Plan.
  - Description of annual reports, 5-year update, and adaptive management.
- **Appendices** (presented in separate volume):
  - Appendix A: CRS Crosswalk
  - Appendix B: 2013 Action Plan Implementation Status
  - Appendix C: Planning Committees
  - Appendix D: Community Engagement Summary
  - Appendix E: Levee Inventory and Levee Failure Inundation Map
  - Appendix F: Dam Inventory and Dam Failure Inundation Map
  - Appendix G: Public Information Activities
  - Appendix H: King County Repetitive Loss Area Analysis
  - Appendix I: Status of Flood Hazard Mapping and Studies
  - Appendix J: Review of Categories of Floodplain Management Activities

1.2 Scope and Purpose of the Flood Plan

The purpose of the 2024 Flood Plan is to establish a shared regional vision for comprehensive flood hazard management in King County that reduces risk to people and property from flooding and channel migration and supports resilient communities and ecosystems. Multi-benefit outcomes, climate change, and equity were primary planning considerations, and the plan is predicated on achieving the desired outcomes through collaborative approaches. Integrated floodplain management concepts were at the core of the Flood Plan development process and are reflected throughout the plan.

King County's most recent flood plans (2006 and 2013) primarily focused on flooding along the county's major rivers. This 2024 Flood Plan is more comprehensive, describing the different types of flooding and flood risks present throughout the county, including coastal hazards, urban and rural stream flooding, and stormwater runoff. Where appropriate, the Flood Plan outlines strategies or next steps for addressing the risks caused by all types of flooding and recommends policies, programs, and projects focused on reducing risk in ways that advance the goals of the NFIP and the ESA. The Flood Plan also supports and elevates the goals of related King County plans and initiatives—including, but not limited to, the following:

- King County Comprehensive Plan[3]
- King County Equity and Social Justice Strategic Plan[4]
- King County Strategic Climate Action Plan[5]
- King County Clean Water Healthy Habitat Strategic Plan[6]
- King County Land Conservation Initiative[7]
- King County Local Food Initiative[8]

The scope of the 2024 Flood Plan is countywide. It characterizes the types of flooding throughout the county, regardless of jurisdiction, and it reflects the reality that multiple governments and community partners carry out flood risk reduction actions. The King County Comprehensive Plan describes the scope of the County's flood risk reduction and floodplain management activities, and the connection to this Flood Plan, as follows: "*King County shall implement a comprehensive local floodplain management program that, consistent with the King County Flood Hazard Management Plan or successor plans: protects lives; minimizes damage and disruption to infrastructure and critical facilities; preserves and restores natural floodplain functions; uses integrated approaches to provide multiple benefits; is resilient to climate change; supports floodplain management actions that benefit frontline communities; and ensures that new development does not put people in harm's way or cause adverse flooding impacts elsewhere.*"[9]

Multi-Benefit Focus

King County has an established track record of implementing projects along the county's waterways that reduce the risk of flooding while providing additional benefits. Recent examples include the Fall City Floodplain Reconnection Project on the Snoqualmie River, the Čakwab Levee Setback and Floodplain Restoration Project on the Green River, the Countyline Levee Setback Project on the White River, and the Riverbend Levee Setback and Floodplain Restoration Project on the Cedar River.

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3 https://kingcounty.gov/en/dept/council/governance-leadership/county-council/topics-of-interest/comprehensive-plan/2024.

4 https://kingcounty.gov/en/legacy/elected/executive/equity-social-justice/strategic-plan.

5 https://kingcounty.gov/en/legacy/services/environment/climate/actions-strategies/strategic-climate-action-plan.

6 https://kingcounty.gov/en/dept/dnrp/about-king-county/about-dnrp/sustainability-commitments/clean-water-healthy-habitat.

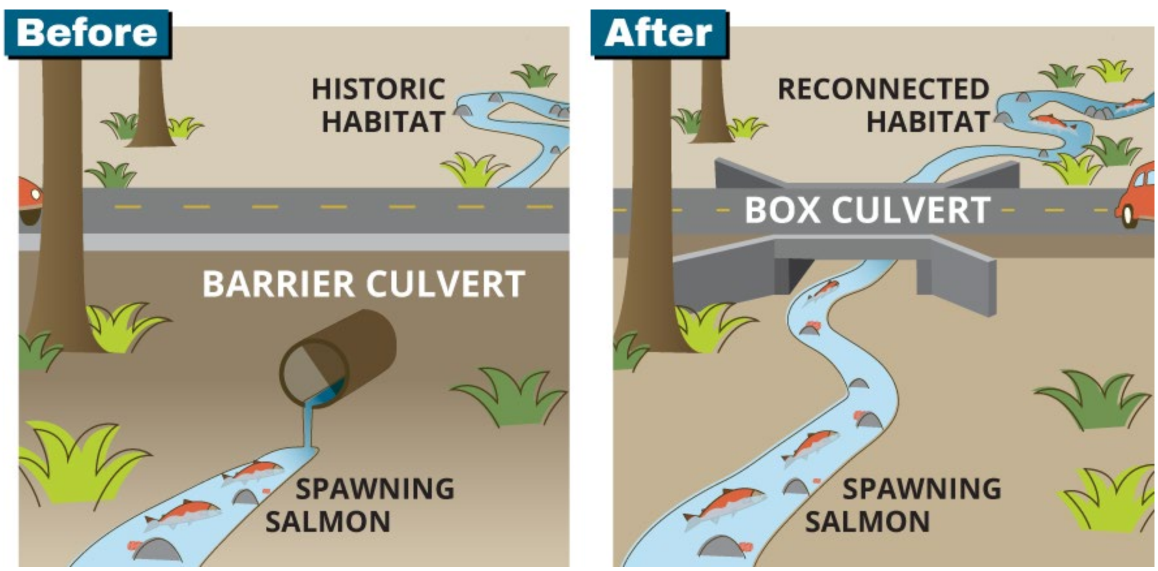
7 https://kingcounty.gov/en/legacy/services/environment/water-and-land/land-conservation.

8 https://kingcounty.gov/en/legacy/elected/executive/constantine/initiatives/local-food-initiative.

9 Policy E-499 in the Executive Proposed 2024 King County Comprehensive Plan: https://cdn.kingcounty.gov/-/media/king-county/depts/council/comprehensive-plan/2024/2023-0440-attachment-a.pdf?rev=84d600c276534543ac4e72ccdfff0a9e&hash=CFCCC4E17D42B996AC44CD7BE471930D.

While King County can point to many examples of multi-benefit project successes, more can be done. The current approach to multi-benefit project planning, development, scoping, and design is not standardized. A concerted effort is needed to bridge different programs and funding sources, each of which has its own objectives (e.g., salmon recovery, open space, flood risk reduction, stormwater management, road improvement, parks, agriculture). Funding restrictions can also present a barrier.

Community members, tribal and local government partners, and other participants in the planning process expressed broad support for multi-benefit flood risk reduction efforts. Common themes shared with King County include providing safe and accessible transportation routes, protecting and restoring natural habitat, preserving green spaces, and supporting jobs and the economy. Despite strong support for multi-benefit solutions, partners identified challenges to implementing these strategies, including competing land uses, the costs of habitat enhancement in urban areas, and balancing nature-based flood risk reduction projects with the protection of agricultural lands. Some partners and community members also highlighted the significant flood risk reduction benefits provided by existing flood control structures, especially for agriculture, ports, and water-dependent business.



King County's culvert replacement efforts have multiple benefits, including restoring access to fish habitat and increasing flow capacity of culverts

Each project is unique, and delivering multiple benefits may not be feasible in all cases. However, this Flood Plan presents an opportunity to establish a framework for how to systematically and holistically approach the planning and development of projects to achieve multi-benefit objectives. In addition to considering adjustments to capital project planning and development, the plan also recognizes programmatic opportunities to enhance delivery of multi-benefit outcomes.

Resilience to Climate Change

Flooding and climate change are inextricably linked. The Pacific Northwest is expected to see changes in weather patterns that will make flooding more frequent, more severe, and with potentially greater consequences. Flooding may get worse where it already occurs, and flooding may happen in places that have not seen flooding before. Some changes already occurring include shifts in rainfall timing and intensity and an increase in the frequency of intense rainfall events.

King County's *Strategic Climate Action Plan* (SCAP), adopted in 2021, outlines ways to integrate climate change into all areas of the County's operations, including work King County does with cities, partners, and communities. A fundamental strategy in the SCAP to prepare for the impacts of climate change is to incorporate potential climate impacts into policies and plans and to implement climate-resilient solutions. The Flood Plan incorporates this strategy by drawing on the latest climate change science to inform the County's understanding of flooding. Recommendations in the plan promote climate resilience by emphasizing the need to plan for future, not present, conditions.

In an online survey distributed as part of the planning effort and described later in this chapter and in Appendix D, planning for future impacts of climate change received the largest number of community responses for how King County can create a flood-resilient future. Communities along King County's marine shoreline and in urban areas are expected to face increased flood risk due to climate change. Community members reported seeing an increasing frequency of storm surge and high-tide flood impacts in coastal areas, such as overtopping roads, property damage, erosion, reduced effectiveness of pumping systems, and extended periods of inundation. Likewise, input shared that overtopping of roads, impacts on businesses, and sediment accumulation in urban areas are occurring due to inadequate capacity for stormwater infrastructure to manage increasing precipitation volumes.

The flood mitigation activities included in King County's 2006 and 2013 flood plans mostly focused on mainstem river flooding. This 2024 Flood Plan addresses changing river flooding conditions, and by including coastal flooding, urban flooding, and tributary flooding, this Flood Plan is responsive to projected climate-driven changes that could pose increased risks to larger areas of the county. As a result, this Flood Plan lays out a more comprehensive approach to reducing flood risk and building resilience, including resilience in the face of climate change.

Equity and Social Justice

Long-standing and persistent inequities exist throughout King County, and these inequities threaten the collective prosperity throughout the region. King County's *Equity and Social Justice Strategic Plan* outlines an array of strategies to move toward the vision of making King County a place where all people have equitable opportunities to thrive. It calls for focusing on where impacts have been the most harmful, centering on Black, Indigenous, and people of color (BIPOC) experiences, addressing root causes or problems, and being responsive, adaptive, transparent, and accountable.

King County's past flood planning efforts approached flood risk reduction from the perspective of physical risk and the need for repair and maintenance of existing facilities that provide protection from flooding or erosion. The County conducts community outreach and engagement during the design of capital projects, but priorities for investment are driven primarily by the location of existing flood protection infrastructure and the physical risk associated with failure of that infrastructure. While the County has taken steps to make information about flood risks and flood preparedness more accessible to people who do not speak English as their first language, the County can do more to engage with the communities most vulnerable to flooding to understand their needs and their capacity to prepare for, respond to, and recover from flooding.

In embarking on this Flood Plan, it was imperative that equity was at the forefront of the County's efforts. For this reason, King County conducted demographic research early in the process to identify who lives in flood hazard areas and how to best reach them. From this understanding, the County developed a community engagement strategy to bring those communities into the planning process. By understanding the needs of those whose voices have not been at the table before, the County will be better able to meet the needs of the most vulnerable communities. Under the plan, King County can shift away from a state of "informing" people of its decisions and toward the "co-creation" of solutions.

King County engagement materials at Washington State Coalition of African Community Leaders Fifth Annual Summit

During the planning process, community members and interested parties identified the scarcity of information and support provided to all communities as equity and social justice concerns, especially for communities for whom English is not the primary language and lower income populations. Beyond providing translated text, input highlighted that some communities would benefit from culturally relevant examples and graphics. Many community members discussed the importance of proactive engagement of vulnerable and historically impacted communities to increase their preparedness and reduce sensitivity to impacts.

1.3 Relationship of Flood Plan to Other Jurisdictions

Floodwaters do not respect jurisdictional boundaries, so actions taken by individual local governments can influence conditions in neighboring jurisdictions. For this reason, partnerships and coordination with cities and other government agencies are essential to achieving the objectives of integrated floodplain management. Coordinated approaches to addressing flood-related risks can help achieve the implementation of holistic solutions that provide multiple benefits.

Many implementers of flood risk reduction activities exist in King County. Furthermore, King County government provides regional services to support and complement the services provided by cities and other governments. The County developed this Flood Plan with the expectation that it will continue to be a strong partner and collaborator in reducing flood risks.

The King County Flood Control District (FCD), a countywide special-purpose district formed in 2007, works to protect lives and property by providing funding to improve the County's aging flood protection infrastructure. The FCD levies a countywide property tax to fund its work and is governed by a Board of Supervisors, which consists of the elected members of King County Council. The King County Executive has no role in establishing the budget or work plan for the FCD.

King County and the FCD maintain an interlocal agreement in which King County is the primary service provider for many FCD services, such as annual monitoring and maintenance of flood and erosion control facilities, flood preparedness and warning services, flood hazard studies and mapping, flood hazard planning and outreach, and implementation of the FCD capital improvement program. The work plan of the FCD is subject to direction by the FCD's Board of Supervisors and set as part of their annual budget adoption.

King County led the development of this Flood Plan and coordinated with the FCD throughout. While the recommendations of the plan have the potential to inform the work of the FCD, the FCD maintains its own budget and decision-making processes separate from the budget and decision-making of King County. This Flood Plan does not direct the work of the FCD in any way.

1.4 Goals and Objectives

Feedback provided through the collaborative efforts of the Flood Plan Partner Planning Committee and an interdepartmental Internal Staff Planning Committee (described later in this chapter), as well as input shared through community engagement, informed the development of the goals and objectives for the 2024 Flood Plan. The following long-term goals and specific objectives set the vision for what King County hopes to achieve and how to go about reducing flood risks to people and property in the county and, in turn, build flood resilience.

The goals for the Flood Plan are:

1. To reduce risks from flooding and channel migration and support resilient, viable communities and economies.
2. To achieve multi-benefit flood risk reduction outcomes that preserve, restore, and enhance the natural functions of flood-prone areas; improve floodwater storage and conveyance; contribute to habitat restoration; honor tribal sovereign rights, including treaty-reserved fishing, hunting, and gathering rights; and meet other needs identified by local communities.
3. To implement flood risk reduction solutions that are comprehensive, community-based, and climate-resilient, and that reduce long-term costs of flood risk reduction.

The Flood Plan's objectives for achieving the above goals are:

1. Apply principles of integrated floodplain management as outlined in Ecology's *Comprehensive Planning for Flood Hazard Management: A Guidebook* to guide flood risk reduction activities.
2. Use the best available science to identify, assess, and monitor flood-related and channel migration hazards, and determine how climate and other future changes may affect risk.
3. Promote public awareness of flood hazards, the actions individuals can take to improve their resilience to flooding, and emergency response programs.
4. Engage local communities, partners, and others in the identification and prioritization of actions and programs that increase resilience and reduce flood risks to life, property, public infrastructure, and public health.
5. Develop flood risk reduction solutions that will be effective over the long term, minimize adverse impacts, are set in a watershed-based context, and consider potential impacts from climate change. Where flood protection facilities already exist, consider feasible multi-benefit alternatives and prioritize the most appropriate long-term solutions.
6. Adopt, consistently implement, and enforce land use management policies and development regulations that prevent the creation of new flood-related and channel migration risks, while preserving or enhancing natural floodplain functions and preventing further habitat degradation.
7. Coordinate regionally with agencies, cities, tribes, nongovernmental organizations (NGOs), and special-purpose districts to assess risk and vulnerability and provide flood monitoring and warning, disaster response, and recovery services.

8. Where other risk mitigation options are not viable or desired, proactively acquire developed or undeveloped properties and permanently remove structures from harm to prevent flood-related and channel migration risks and support multi-benefit goals.
9. Improve access to programs that help county residents, businesses, and other institutions prepare for and recover from flooding beyond traditional flood insurance.
10. Collaborate regionally to identify funding sources to implement flood risk reduction activities and identify opportunities, strategies, and partnerships to leverage grant funding and partner investments.
11. Use adaptive management to adjust actions based on scientific and technological advances, including best available information on floodplain and flood management practices and principles, project effectiveness monitoring information, understanding of risk, and equity considerations.
12. Use data related to social vulnerability, land use, jobs, and business activity to inform how, when, and where flood risk reduction activities are prioritized and implemented.

1.5 Guiding Principles

Guiding principles are statements that describe King County's technical understanding of conditions or characteristics that inform and provide direction to flood risk reduction activities. The guiding principles represent a shared understanding of the context surrounding flooding and the actions the County can take to reduce risk and increase resilience. The collaborative work of the Partner Planning Committee, the Internal Staff Planning Committee, and community engagement input informed the development of these statements. The Flood Plan's 15 guiding principles, divided into four categories, are:

Equity and Community Priorities

1. Factors that influence social vulnerability, such as age, race, health, education, mobility, and income, must be considered and applied when monitoring hazards, identifying risks, and developing flood risk reduction solutions.
2. King County's floodplains and flood-prone areas exhibit many different activities and land uses and include developed areas with homes, farms, businesses, industry, recreation amenities, and infrastructure that are valued by King County and its communities. Scoping and evaluation of flood risk reduction strategies should consider the existing development and land use context.

Natural Environment

3. Federal and state guidance from FEMA and Ecology prioritize working with natural systems, finding nonstructural solutions to flood problems, and restoring ecological functions as an element of flood risk reduction. King County recognizes that flooding and erosion are natural processes that sustain biological productivity and diversity, acknowledges the ecological and bank stability benefits of riparian vegetation, and prioritizes nature-based flood risk reduction solutions where possible.

4. Protecting and enhancing natural processes can provide environmental benefits, increase climate change resilience, and reduce flood risks to people and property in a less costly manner than structural flood control approaches.
5. Rivers and streams and their floodplains, coastal areas, and riparian areas provide habitat for salmonids, including several that are listed as threatened under the ESA. Salmon are intricately connected to Native American culture and tribal rights.

Risk Management

6. Areas behind levees, downstream of dams, or outside of mapped flood hazard areas have a residual risk of flooding (for example, from potential levee failure).
7. Flooding and channel migration are influenced by past and current land use and land management decisions (including actions in upland portions of watersheds), stormwater flows, and climate change.
8. Flood control methods can reduce some flood damage, but those methods require maintenance, do not eliminate all risk, and may not be adaptable to changing conditions.

Best Practices

9. Actions to address flood risk to existing development must consider the existing land use context, other land uses and interests (such as urban development, fish and wildlife habitat, open space, agriculture, recreation, and transportation), climate change, and other future landscape changes.
10. Flood damage creates public and private financial costs, and effective flood risk reduction reduces long-term flood damage costs.
11. Consultation with tribes and engagement with and involvement of residents, resource management agencies, flood-vulnerable communities, and public and private landowners are vital in developing and implementing risk reduction strategies and a responsible, equitable, and effective Flood Plan.
12. Coordination and cooperation among local, regional, state, and federal agencies are essential for the success of long-term comprehensive flood hazard management. Where possible, seek to harmonize overlapping and sometimes conflicting regulations and standards that apply to flood hazard areas.
13. Evaluation of capital project design alternatives must carefully consider off-site flood impacts, equity and social justice implications, ecological consequences, impacts on ESA-listed salmon, and long-term costs of action or no action.
14. Identifying flood risks and selecting the most effective flood risk reduction solutions for the long term should be informed by the best available science, best practices in floodplain management, multi-objective and multi-benefit considerations, and community engagement.
15. Scoping and evaluation of alternatives to address flood and channel migration risks should actively seek opportunities to achieve multi-benefit outcomes and net ecological gain.

1.6 Policies

This Flood Plan outlines a countywide vision for flood hazard management and flood risk reduction and addresses various types of flooding, such as river, tributary, coastal, and urban flooding. This comprehensive Flood Plan emphasizes a coordinated, adaptive, and innovative approach to managing flood hazards and reducing risk, preserving the viability of communities and economies, and enhancing ecosystem functions. The Flood Plan strives to build flood resilience for King County and its communities and seeks to leverage the necessary resources and support for multiple benefits associated with flood risk reduction efforts.

The Flood Plan is adopted by King County Council as a functional plan of the King County Comprehensive Plan, meaning that it augments and helps implement the Comprehensive Plan and guides daily management decisions. The Flood Plan details King County's policies for the protection of frequently flooded areas and floodplain management, and the Comprehensive Plan, in policy E-499r10, states that "King County's floodplain land use and floodplain management activities shall be carried out in accordance with the policies, programs, and projects detailed in the King County Flood Hazard Management Plan or successor plans."

The following 22 policies provide the framework for King County's decision-making about flood risk reduction and floodplain management and provide guidance for project- and program-level decisions by King County agencies and recommended approaches countywide.

Equity

King County acknowledges that social, economic, and environmental inequities threaten the collective prosperity of the region. King County also acknowledges the presence of factors beyond physical risk that can influence people's vulnerability to flooding and their ability to recover from flood impacts. This Flood Plan identifies ways to increase flood preparedness and build flood resilience countywide, especially for those communities that are most vulnerable to the effects of flooding. The following is a list of county policies that address the issue of equity in flood reduction efforts:

1. Consistent with King County Comprehensive Plan policies RP-101 and RP-102,[11] King County shall apply equity and social justice principles throughout the planning and implementation of the King County Flood Hazard Management Plan to ensure that property owners and residents are given equitable access to flood risk reduction services.
2. The identification, prioritization, design, and implementation of flood risk reduction activities, including preparedness and emergency services, shall consider the needs of and impacts on vulnerable populations that may face barriers to accessing services and

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[10] From Executive Proposed 2024 King County Comprehensive Plan: https://cdn.kingcounty.gov/-/media/king-county/depts/council/comprehensive-plan/2024/2023-0440-attachment-a.pdf?rev=84d600c276534543ac4e72ccdfff0a9e&hash=CFCCC4E17D42B996AC44CD7BE471930D.

[11] From Executive Proposed 2024 King County Comprehensive Plan.

programs based on age, income, disability, English language proficiency, race, ethnicity, or other factors affecting social vulnerability.

3. When considering flood risk reduction alternatives that involve property acquisition, King County shall evaluate whether there will be impacts on renters, low-income communities, and communities of color, including displacement. King County shall work with the affected community through open and transparent communication to identify how to increase flood resilience while avoiding displacement and adverse impacts on housing affordability and supply.
4. King County shall implement community engagement focused on flood resilience and shall partner with and build capacity within community-based organizations supporting or led by historically underserved populations to achieve mutually beneficial outcomes, such as flood preparedness education, flood warning, and flood risk reduction projects.

Natural Systems

Historical practices for flood risk reduction removed wood and sediment from waterways; built flood risk reduction infrastructure such as dams, levees, and revetments that disconnected rivers from their floodplains; reduced active channel areas; armored shorelines; and, in turn, severely damaged aquatic and riparian habitat and food webs that are dependent on these natural processes. Scientific advances have demonstrated that flood risk reduction methods that rely on heavily engineered solutions are often expensive, provide only temporary, short-term relief from flooding, and can encourage development in at-risk areas. Climate change exacerbates these concerns.

Some floodplain areas in King County, particularly within more developed or urbanized areas, contain development that is unlikely to be removed or relocated, but some amount of environmental enhancement is often possible in these locations. Additionally, flood-prone areas in less developed parts of the county provide opportunities for floodplain reconnection and restoration. Integrated floodplain management seeks to restore natural, habitat-forming processes and ecosystem function while maximizing flood risk reduction. This approach recognizes that natural systems provide flood risk reduction benefits by slowing runoff and storing, infiltrating, and conveying floodwaters. King County flood risk reduction policies that reflect the importance of protecting natural systems include the following:

5. King County shall seek to preserve and enhance natural functions of flood hazard areas and promote natural hydrologic function at the watershed scale to build resilience to changing precipitation patterns in a changing climate.
6. When scoping alternatives for repairing or rebuilding existing flood protection facilities, King County shall evaluate opportunities to relocate existing flood protection facilities farther from the water's edge and implement associated buffers to increase flood storage and conveyance to reduce risk, allow sediment and wood deposition and other natural processes to occur, and support resilience to climate change.
7. King County shall look for opportunities to improve the resilience of existing infrastructure, including decommissioning or removing infrastructure that no longer serves its intended purpose. Further, the County shall prioritize decommissioning or

removing such infrastructure in locations that enable restoration of natural processes that reduce flood risk and provide other multi-benefit outcomes.

8. King County shall engage landowners and renters of at-risk properties to identify viable strategies for flood risk reduction. These strategies shall include acquisition and long-term maintenance of flood-prone property as a tool to reduce or permanently eliminate localized flood risk, improve management of surface water or runoff, implement multi-benefit flood risk reduction projects, or advance of the goals of King County's Land Conservation Initiative, Clean Water Healthy Habitat Initiative, Water Resource Inventory Area (WRIA) salmon recovery plans, or other adopted basin, stormwater, agricultural, or open space plan.
9. King County shall only pursue gravel or sediment removal for flood risk reduction purposes as part of congressionally authorized projects, multi-benefit projects that provide a net gain in habitat functions and values, or to prevent or address threats to critical infrastructure. As much as possible, King County should only remove gravel or sediment from inactive river and stream channels.
10. King County acknowledges that the presence of natural wood in rivers and streams and their floodplains is integral to sustaining the ecological functions critical for salmon and aquatic ecosystems, and, consistent with salmon recovery plans, the County should allow as much natural wood as possible to function as part of these dynamic systems to support critical habitat for salmon species listed as threatened under the ESA.

Multiple Benefits

King County recognizes that flood-prone areas exhibit diverse land uses that are valued by King County and its communities, including developed landscapes that support regional economic activity. King County also acknowledges that flooding and erosion are natural processes that sustain biological productivity and diversity. Consistent with King County Countywide Planning Policies EN-2 and EN-3,[12] effective flood risk reduction increases floodwater storage, infiltration, and conveyance; reduces flood damages; and increases the resilience of King County's communities and economies while also supporting and enabling a range of other beneficial outcomes as described in the following policies:

11. King County should seek to achieve comprehensive flood hazard management that effectively addresses flood risk reduction needs while also honoring tribal sovereign rights, including treaty-reserved fishing, hunting, and gathering rights; seeking opportunities to protect and restore natural floodplain functions; and supporting the interrelated interests and needs of the communities and land uses in which the work takes place. Outcomes shall center on equity and environmental justice and will aim to be achieved through partnership with local governments, tribes, special-purpose districts, community groups, and other entities. Specific multi-benefit outcomes could include:
    - Communities, public infrastructure, and functioning ecosystems that are resilient to climate change.

[12] 2021 King County Countywide Planning Policies, https://kingcounty.gov/~/media/depts/executive/performance-strategy-budget/regional-planning/CPPs/2021_CPPs-Adopted_and_Ratified.ashx?la=en.

– Habitat protection and restoration for fish and wildlife, including salmon.
– Productive, viable agriculture.
– Safe and sustainable development.
– Jobs and sustainable livelihoods and economic development.
– Clean water.
– Open space conservation.
– Recreation and other opportunities to connect people with nature.

12. King County shall identify floodplain reconnection and multi-benefit flood risk reduction projects and actively include multi-benefit considerations in scoping and alternatives analysis for flood risk reduction projects, including identifying opportunities to provide benefits beyond flood risk reduction in developed landscapes that are consistent with public safety goals.

Climate Change

As outlined in King County's SCAP, climate change is expected to produce shifts in weather patterns in the Pacific Northwest that will alter flooding characteristics and very likely increase flooding risk. This will result in additional impacts on the regional economy, public health and safety, and the environment. King County acknowledges that currently mapped flood hazard area boundaries likely understate risk, making it of paramount importance to manage flood risks with future conditions in mind using the best available science (consistent with Countywide Planning Policy EN-8). Policies that consider the potential future impacts of climate change include the following:

13. King County shall develop and implement a climate change capital planning strategy for flood risk reduction projects and communicate potential future risk in flood preparedness and community engagement.
14. King County shall continue to expand its understanding of the potential implications of a changing climate on flood conditions and other natural hazards that may affect flooding. King County shall use the best available science about climate change to identify potential future flood and flood-related hazards and risks and to inform land use planning and regulations, flood preparedness and flood warning services, flood mitigation services, and other infrastructure and development decisions. This will include changes in freshwater flooding conditions and changes resulting from sea level rise.
15. Given the uncertainty associated with climate change impacts, King County shall include additional factors of safety in flood hazard area regulations and apply additional factors of safety to the design standards for flood risk reduction, stormwater, and other critical infrastructure projects.

Coastal flooding of Dockton Park on Maury Island, December 2022

Land Use and Regulatory Compliance

King County regulates development in flood hazard areas in unincorporated King County through the Critical Areas Ordinance (King County Code, Title 21A.24[13]). Flood hazard areas covered by King County's regulations include both the 1 percent annual chance floodplain and channel migration zones. The best way to avoid impacts from flooding and flood-related hazards is to avoid development within flood hazard areas, yet King County allows some development to occur within these zones. Also, the boundaries of mapped flood hazard areas periodically change to include developed properties not previously mapped as flood hazard areas. Development standards are intended to minimize risks to people and property and to avoid risk to other properties upstream or downstream of the development. King County's flood hazard reduction policies, as they relate to land use and regulatory compliance, are as follows:

16. As required by FEMA's CRS program, King County shall exceed the minimum standards of the NFIP and be consistent with the NFIP Biological Opinion and habitat restoration obligations under the ESA.
17. King County shall regulate development that occurs in flood-prone areas to avoid and minimize damage to life and property and necessary public infrastructure, support other

[13] https://kingcounty.gov/en/legacy/council/legislation/kc_code/24_30_Title_21A.aspx.

Washington State Growth Management Act (GMA) and King County Comprehensive Plan policy goals, accommodate preferred land uses outlined by the Shoreline Management Act (described later in this chapter), and recover salmon species listed under the ESA.

18. King County should look for opportunities to improve, modify, or relocate existing county roads to ensure safe ingress and egress during flood events.

Integrated Floodplain Management

King County values innovation and is committed to understanding and reducing the adverse impacts associated with flooding. The County also recognizes the need for location-specific solutions depending on existing land uses and seeks to integrate flood risk reduction efforts with other community needs and objectives within watersheds and geographic scales larger than a specific project site. Areas of emphasis include equitable and inclusive collaboration and coordination involving cities, counties, tribes, special-purpose districts, salmon recovery planning groups, and state and federal agencies to ensure comprehensive and effective alignment of flood management across jurisdictions. Integrated flood plain management policies include the following:

19. Consistent with federal and state guidance, King County's flood risk reduction strategies shall focus first on hazard mapping and preventative risk avoidance, followed by preparedness and mitigation actions to reduce vulnerability and protect public health and safety. King County shall also develop expertise and tailored strategies that meet the unique needs and characteristics of the region, including nonstructural alternatives and ecological restoration, and all county departments shall implement activities consistent with the policies in this Flood Plan.
20. King County's flood risk reduction efforts shall be planned and implemented in close coordination with cities, counties, tribes, special-purpose districts, salmon recovery planning groups, and state and federal agencies. King County shall also coordinate with other local governments and encourage regional collaboration so that risks are not transferred from one jurisdiction to another.
21. King County shall coordinate with dam owners and operators on communication of downstream risks associated with high-hazard dams. King County shall also participate in dam relicensing, review of proposals for new dams and impoundments, and other efforts related to operational procedures of dams to promote the multi-benefit objectives articulated in this Flood Plan.
22. King County shall implement flood risk reduction measures that reduce flood damages and long-term costs and shall leverage revenues through funding partnerships with other agencies and through diverse funding streams and grants that support multiple benefits.

1.7 Planning Process

King County participates in the NFIP CRS, which is a program that encourages communities to exceed the minimum standards of the NFIP. By doing so, property owners within unincorporated King County are eligible for flood insurance premium discounts (the amount of the discount being determined by the class rating). King County developed the 2024 King County Flood Management Plan consistent with the CRS 10-step planning process described in CRS Activity 512.a. The planning process also followed the guidance provided in Ecology's *Flood Hazard Management Planning Guidebook*.

During the project pre-planning phase, King County developed a structure to engage a wide range of partners and community members in the planning process to ensure that engagement was central to the development of the Flood Plan. The main elements included the formation of a Partner Planning Committee, an Internal Staff Planning Committee, and a Coordinating Committee; facilitation of topic-specific workshops; and direct community engagement, each of which is described in more detail below.

CRS 10-Step Flood Management Plan Process

1. **Organize to prepare the plan**: Determine who will be involved in developing the plan.
2. **Involve the public**: Provide opportunities to contribute to the planning process for members of the public, through committees, public meetings, and other means.
3. **Coordinate**: Work with other agencies and organizations to incorporate their plans and efforts into the flood management plan.
4. **Assess the hazard**: Review, analyze, and summarize data on flood characteristics.
5. **Assess the problem**: Collect and summarize data on flood impacts experienced by the community.
6. **Set goals**: Develop goals that address flood impacts identified in Step 5.
7. **Review possible activities**: Discuss pros and cons of a wide array of flood risk reduction activities.
8. **Draft an action plan**: Select appropriate risk reduction actions that the community can commit to implementing.
9. **Adopt the plan**: The governing body of the community adopts the official plan.
10. **Implement, evaluate, revise**: Monitor implementation progress and evaluate opportunities to improve implementation.

Source: CRS Coordinator's Manual (FEMA 2017)

Partner Planning Committee

King County established the Flood Plan Partner Planning Committee in 2022 as the primary committee to support and inform the development of the Flood Plan. The committee served as a central venue for sharing information and ideas about flooding and flood risk reduction countywide, and it fulfilled FEMA's CRS Step 2 requirement that the planning process involve the public.

The committee advised and provided input and direction on topics such as updating goals, objectives, and guiding principles; discussing approaches to address priority floodplain and flood hazard management issues; and on appropriate floodplain management strategies and actions to address expected flood risks. The committee met nine times from late 2022 through 2023 to discuss these topics.

Committee members represented local and state governments, tribal government, NGOs, interest groups, floodplain residents, and community members. This diverse representation of community members, governments, and interests throughout King County was integral to developing a Flood Plan that thoughtfully addresses the needs of vulnerable populations, natural and cultural resources, urban and rural areas, and an array of industries. King County staff also participated in this committee, including the County's Floodplain Administrator and staff representing various disciplines. A full list of committee members is provided in **Appendix C**.

Internal Staff Planning Committee

Given the breadth of King County work programs either affected by or with a connection to flooding and floodplains, the County established an Internal Staff Planning Committee. This committee provided a forum for county work program priorities to be shared and heard, potential conflicts identified, and policy implications of various options considered. This cross-departmental team served as a sounding board for key policy and regulatory challenges and helped identify options for resolving these challenges. The committee met nine times from early 2022 through 2023. Participants represented King County permitting, river and floodplain management, emergency management, road services, parks and recreation, stormwater services, agriculture, land acquisition, ecological restoration, climate change, and science programs. A full list of committee members is provided in Appendix C.

Coordinating Committee

The King County Flood Control District (FCD) is a special-purpose district independent from King County government, and coordination between the FCD and the County occurred through an intergovernmental team called the Coordinating Committee. This team provided advice on scope, schedule, and approach for updating the Flood Plan, particularly on issues where King County and FCD policies, funding, and decision-making roles intersect. The committee also helped to anticipate and plan for Executive, Council, and FCD Board review and consideration of the Flood Plan. The committee met 13 times from early 2022 through 2023.

Topic-Specific Workshops

Since flooding and flood-related hazards extend beyond King County's mainstem rivers to include tributaries, coastal shorelines, and urban areas, King County hosted a series of workshops to gather perspectives from tribes, partners, and community members on tributary, coastal, and urban flooding (two workshops for each topic). King County structured the workshops to hear from participants about flood hazards, specific problem areas, impacts associated with those problems, and potential solutions to consider in the Flood Plan.

Tribal Consultation

King County consulted with tribal governments during the planning process to ensure that the Flood Plan incorporates proper consideration of tribal rights and tribal resources. County staff briefed tribal natural resources program staff, invited tribes to participate on the Flood Plan Partner Planning Committee and in topic-specific workshops, and requested tribal comment on the SEPA review (described later in this chapter).

Community Engagement Strategy

King County acknowledges that past flood plan public involvement opportunities did not do enough to remove barriers to participation or support community-led solutions. To address these issues, King County developed a comprehensive community engagement strategy (see Appendix D). The strategy served as a roadmap for how King County would improve opportunities for community engagement in the development of the Flood Plan.

The community engagement strategy is based on feedback from the public, community organizations, agency management, academic research, responses to an online survey, informational interviews with eight community group leaders who represent underserved communities in King County, and five floodplain management-focused government agencies.

King County desires to reduce the impacts of flooding and help people recover from flooding more quickly. By developing a comprehensive community engagement strategy, King County was able to identify concrete steps to raise community awareness of flooding issues, local flood risk, and opportunities to reduce flood risk and build flood resilience for communities, households, and businesses. The strategy also identified approaches to gather public feedback related to flooding in a way that centers people and communities most impacted by flooding.

King County used the following engagement strategies to gather community input into the draft Flood Plan, as well as to raise awareness about flooding issues and resources available to increase flood resilience:

- **Community partnerships**: King County invited community-based organizations and individuals who are connected to priority communities to enter a contracted and funded partnership with the County. The partnership focused on collaborative co-design and implementation of customized outreach and engagement plans targeting one or more priority communities.
- **Community visits**: King County solicited invitations to local events and meetings to reach priority audiences based on demographic characteristics and geographic representation.
- **Online polling and email network**: An online engagement hub, including a three-phase online survey, was available throughout most of the Flood Plan development process. Email was used for sharing monthly announcements and updates.

- **Public meetings and workshops**: King County hosted virtual meetings and workshops, including two public kickoff meetings at the beginning of the planning process and at a point when the focus of planning was shifting into seeking input on strategies.
- **Targeted and paid advertising**: As an alternative way to reach priority communities and drive people to resources about flooding and the Flood Plan, King County implemented two advertising approaches. One involved running an ad campaign with an ethnic media company serving African American and immigrant populations, while the second involved signs and posters on buses in east and south county areas, on light rail, and at three transit stations.

Messaging, graphics, and communication products supported meaningful engagement throughout the planning process. Products focused on audiences new to the topic of floodplain management and were deployed in multiple settings. In most cases, these materials were translated into several languages.

Community outreach at Pacific Days festival, July 2023

1.8 Integration with State Environmental Policy Act (SEPA)

The Washington State Environmental Policy Act (SEPA) governs the process to identify and analyze environmental impacts associated with governmental actions and decisions. To identify and evaluate the potential environmental impacts of the new Flood Plan and comply with SEPA requirements, King County prepared an Environmental Impact Statement (EIS). An EIS is a tool that describes proposed actions and analyzes how those actions may affect the environment.

Through the Flood Plan EIS, King County analyzed potential impacts of the Flood Plan on threatened or endangered species, water quality, historical and cultural resources, transportation, and other elements of the environment. Additionally, given that King County expanded the focus of this Flood Plan beyond mainstem rivers in mostly rural communities, the EIS serves as a tool to evaluate how this broader scope could affect natural and built environments throughout all of King County.

The Flood Plan SEPA process followed the requirements established by RCW Section 43.21C[14] and guidance outlined in Ecology's *State Environmental Policy Act Handbook*. The 2024 King County Flood Management Plan is a "non-project proposal" under SEPA, which entails high-level review of impacts, alternatives, and mitigation measures for a broad program of actions, as opposed to detailed evaluation of specific project actions. A "non-project proposal" provides a foundational environmental analysis for future review of specific projects that can help to reduce the burden of environmental review for each project.

King County issued a scoping notice and Determination of Significance (DS) in November 2022. The scoping notice included a description of the alternatives that would be analyzed in the EIS and a list of the elements of the natural and built environment that the EIS would consider. All cities in King County, all tribes, and state and federal agencies were notified. The scoping period was also announced through a news release to local media and was distributed to a large email list. Scoping carried a 30-day public comment period, and 18 comment letters were submitted. Following the consideration of scoping comments, the County prepared a Draft EIS. King County will release the Draft EIS for public comment concurrent with the draft Flood Plan.

1.9 Other Regulatory Drivers and Commitments

In addition to SEPA (as described above), the Flood Plan was developed to comply with several regulatory requirements, as well as to fulfill other, nonregulatory commitments and obligations.

[14] https://app.leg.wa.gov/rcw/default.aspx?cite=43.21c.

National Flood Insurance Program (NFIP) and Community Rating System (CRS)

FEMA manages the NFIP, which provides federally backed flood insurance to property owners, renters, and businesses located in some flood hazard areas. This insurance coverage helps those affected by flooding recover faster following flood damage. For this coverage to be available to community members, the local government must be a participating community, which requires that the community adopt and implement certain floodplain management regulations designed to reduce future flood risk. King County is an NFIP-participating community and, as such, the recommendations in this Flood Plan must meet minimum NFIP standards to ensure that NFIP flood insurance remains available to county residents.

FEMA's CRS is a voluntary program that encourages floodplain management activities that exceed NFIP minimum standards. Under the program, flood insurance policyholders who live in jurisdictions that implement floodplain management activities that exceed NFIP minimums may receive a discount on their insurance premiums. King County has been among the highest-rated counties in the nation in CRS for several years and, at the time of plan development, King County's CRS rating is Class 2 (which provides a 40 percent flood insurance premium discount to policyholders in unincorporated areas). To maintain King County's standing in the program, this Flood Plan followed the CRS 10-step planning process described in CRS Activity 512.a (see the sidebar on page 1-19, as well as the CRS Coordinator's Manual[15] for more information).

State Planning Requirements

RCW Section 86.12.210[16] authorizes the legislative body of any county to adopt a comprehensive flood hazard management plan for any drainage basin located wholly or partially within the county. Chapter 173-145-040[17] of the Washington Administrative Code (WAC) outlines the requirements for comprehensive flood control management plans and specifies Ecology's role in approving these plans.

A comprehensive flood hazard management plan must also be developed within King County's planning framework, which implements the requirements of the Washington State GMA. The Flood Plan is adopted as a functional plan under the umbrella of the King County Comprehensive Plan. As such, the Flood Plan outlines the policies for protecting frequently flooded areas, as required by GMA.

15 https://crsresources.org/manual/.

16 https://app.leg.wa.gov/RCW/default.aspx?cite=86.12.210.

17 https://app.leg.wa.gov/wac/default.aspx?cite=173-145-040.

Endangered Species Act (ESA)

The ESA is a federal law that prohibits the importation, exportation, taking, and commercialization of fish, wildlife, and plants listed as threatened or endangered species. Flood hazard management activities must balance risk reduction with protection of listed species, as well as their habitats and components of the ecosystem upon which they rely. Protection of threatened and endangered aquatic species is particularly relevant to flood hazard management activities because activities that change water bodies and floodplains can have harmful impacts on habitat, water quality, and food sources relied upon by aquatic species.

In Puget Sound, Chinook salmon, steelhead, and bull trout are listed as threatened under the ESA. All major rivers in King County, many tributaries, Lake Washington, Lake Sammamish, and the sound's entire marine shoreline comprise critical habitat for these listed species. Additionally, salmon (in particular, Chinook salmon) are a primary prey resource for southern resident orca, listed as endangered under the ESA since 2005. Flood risk reduction capital projects, which often affect water bodies, shorelines, and floodplains, influence habitat in positive or negative ways. Flood risk reduction projects and salmon habitat are inextricably linked.

The Puget Sound Salmon Recovery Plan was drafted in 2005 and adopted by the National Oceanic and Atmospheric Administration (NOAA) in 2007 as a path to recover threatened and endangered Puget Sound salmonid species. The Puget Sound Salmon Recovery Plan aims to achieve self-sustaining salmon populations that would support delisting of Puget Sound salmonid species, tribal fishing rights, economic vitality, and environmental health (NMFS 2007). Watershed-based recovery plans are components of the regional plan, and their implementation is guided by watershed forums comprised of partners from local, state, and federal governments, tribes, and NGOs. Through this integrated, highly collaborative framework, King County protects species and the ecosystems they rely on and actively leads an array of restoration efforts that support recovery.

Clean Water Act

The Clean Water Act is a federal law that regulates pollutants and the quality of water that enters surface waters. The Clean Water Act dictates requirements for the management of public and private stormwater and wastewater systems. King County implements a Phase I Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) permit and associated activities for compliance with Clean Water Act regulations that aim to reduce runoff, while improving the treatment and storage of stormwater and wastewater. As climate change results in more extreme precipitation, managing stormwater runoff will be critical to both mitigating urban flooding and meeting permitting requirements under the Clean Water Act to limit the discharge of untreated water from combined stormwater and sewer systems.

Shoreline Management Act

The State of Washington's Shoreline Management Act (Chapter 90.58 RCW[18]) requires all counties in the state to develop Shoreline Master Programs, which are sets of regulations that dictate land use, environmental protection, and public access standards for shoreline areas. The Shoreline Management Act applies to marine waters, streams, rivers, lakes, and wetlands, as well as areas within 200 feet of these water bodies and the 1 percent annual chance floodplain. Shoreline Master Programs outline preferred land uses for shoreline areas, including single-family residences, shoreline recreational uses, ports, water-dependent industrial and commercial uses, and other developments providing public access opportunities. The Shoreline Management Act is structured to protect natural resources and requires mitigation to offset environmental impacts from allowable shoreline land uses. Shoreline Master Programs must also provide for public access to publicly owned shorelines and support access to public waters and tidelands.

King County's Shoreline Master Program aligns with the integrated floodplain management approach to this Flood Plan. The protection of habitat and ecological functions, including those in floodplains, supports natural processes that mitigate flood risk and balances the interests of water-dependent industries, shoreline property owners, and recreational users.

Local Requirements and Commitments

In addition to the regulatory drivers identified above, King County is committed to achieving a range of other outcomes that directly or indirectly relate to floodplains, flood hazard areas, and some of the above-referenced regulations. A summary of these is as follows:

- **Clean Water Healthy Habitat –** Adopted in 2020, King County's Clean Water Healthy Habitat (CWHH) Strategic Plan is intended to guide investments to improve water quality and aquatic habitat conditions. Of the six primary goal areas identified in the plan, five goal areas directly relate to topics addressed in this Flood Plan: healthy forests and more green spaces, cleaner and controlled stormwater runoff, functional river floodplains, better fish habitat, and resilient marine shorelines. For example, if CWHH is successful, there will be a 3,000-acre net increase in connected floodplain with native vegetation.
- **Climate Change –** The King County Strategic Climate Action Plan (SCAP) outlines actions the County can take to increase resilience to the effects of climate change. Flood risk reduction activities—especially capital projects implemented to address flood risks—can directly improve on-the-ground conditions in ways that enhance the ability of ecosystems to accommodate and adjust to changes in climate conditions.
- **Land Conservation –** King County's Land Conservation Initiative (LCI) is a regional collaboration among King County, cities, businesses, farmers, environmental partners, and others to preserve the most important remaining natural lands and urban green spaces over the next 30 years. One of the six priority land categories targeted under this initiative is river corridors, with a focus on reducing flooding and sustaining salmon runs.

[18] https://apps.leg.wa.gov/rcw/default.aspx?cite=90.58.

- **Local Food –** King County launched the Local Food Initiative in 2014, and it supports farmers and protects farmland in the county. Part of the overall strategy behind the Local Food Initiative is to ensure the continued viability of agriculture in King County. Many of the most productive agricultural lands in the county are located within river floodplains, and part of the reason they are so productive is because of flooding and the natural deposition of nutrient-rich sediment in these areas. As a result, this Flood Plan has a direct connection to the needs of farming communities.
- **Fish Passage Restoration Program –** Fish passage barriers limit the ability of native salmon to reach their spawning grounds, and removing those barriers is one of the most straight-forward habitat improvements that can be made to ensure the continued survival of salmon. King County's Fish Passage Restoration Program is focused on restoring passage at barriers that block access to the best habitats. Doing so will not only improve instream conditions for fish but may also reduce risk of roadway damage due to water backing up behind undersized or blocked culverts.
- **King County Regional Hazard Mitigation Plan –** The King County Regional Hazard Mitigation Plan[19] is a multi-hazard plan that assesses natural and human-caused hazards that can impact the Puget Sound region and outlines strategies to reduce risks from those hazards and build resilience. The plan includes flooding as one of the many hazards addressed, yet it defers detailed discussions of flooding and flood risk reduction solutions to this Flood Plan.

[19] https://kingcounty.gov/en/legacy/depts/emergency-management/emergency-management-professionals/regional-hazard-mitigation-plan.

CHAPTER 2

Flooding in King County

This chapter describes the types of flooding and flood-related hazards most-often observed in King County. Flooding occurs in many locations in the county, and the types of flooding and the risks it presents to people, property, and infrastructure are numerous and vary by location. This chapter is divided into seven sections. The first section (**Section 2.1**) provides an overview of the types of flooding addressed by this Flood Plan. The four sections that follow describe the primary flood and flood-related hazards and risks by King County's four major river watersheds:

- South Fork Skykomish/Snoqualmie River (**Section 2.2**)
- Lake Washington/Cedar/Sammamish River (**Section 2.3**)
- Green/Duwamish River (**Section 2.4**)
- White River (**Section 2.5**)

Section 2.6 describes the flooding characteristics for three new areas of focus for King County's flood planning: tributary flooding, urban flooding, and coastal flooding. The final section (**Section 2.7**) summarizes the impacts of flooding at the countywide scale and summarizes the results of the countywide flood hazard risk assessment performed using FEMA's Hazus Risk Assessment Platform.

2.1 County Context: Primary Flooding Types Considered by this Food Plan

River Flooding

King County's floodplains reflect a geologic present and past that include large-scale tectonic and volcanic processes that occurred over tens of millions of years; several periods of extensive glaciation, the latest of which ended about 15,000 years ago (Booth et al. 2003); and at least one major mudflow, the Osceola Mudflow, which occurred roughly 5,700 years ago. Tectonic and volcanic processes created large-scale landforms, such as the Cascade and Olympic Mountain ranges, the Olympic Peninsula, and Puget Sound. More recent glaciers and mudflows shaped many of the lowland surface features apparent today, including the topography and soils of King County's lowland river valleys. Alpine glaciers are still present in headwater basins of the White, Snoqualmie, and South Fork Skykomish rivers, and the character of glaciers is changing as climate change increases their melting and as glacial recession exposes new sediment sources.

Lower Snoqualmie River flooding near Duvall, December 2015

Earthquakes occur periodically along active faults within several fault zones in King County and have the potential to cause tsunamis and compound flood hazards when they occur during flood events. Earthquakes may also induce landslides that dam rivers, resulting in upstream flooding. These processes and events have influenced the length, width, steepness, sediment load, and channel forms of King County's large rivers and major tributaries and continue to shape the region today.

The headwaters and middle reaches of rivers in King County are typically steep and dominated by bedrock, boulders, and landslides. These areas are major sources of sediment transported downstream by rivers and streams, and floodplains in these reaches are often narrow or absent. Middle reaches are less developed than the river systems in lowland areas, but mountain valley roads and small residential communities in these areas can be impacted by erosion and fast flows from river and tributary flooding. When the rivers eventually reach the Puget Sound lowlands, they flatten out, deposit sediments carried down from upstream, and form floodplains that are often broad, ecologically complex, and biologically productive.

Native American tribes have had a continuous, active presence in what is now King County for thousands of years. These lands provide critical habitats for fish and wildlife, and hunting and gathering have occurred in the region since time immemorial. In the relatively brief time since Euro-American settlement began in the Puget Sound basin, development has extensively altered the region's river floodplains—perhaps nowhere more so than in King County. Early land-clearing and installation of drainage systems to support farming, mining, and transportation transitioned throughout the 20th century to more extensive modifications that allowed for ever-expanding residential, commercial, and industrial development. These efforts disconnected formerly forested and vegetated floodplains from watercourses and converted them to developed land uses. Rivers and streams were entirely rerouted, wood was removed from floodplains and channels, banks were armored with rock, and dams were constructed for water supply, flood control, and hydropower.

Alterations to the region's floodplains caused substantial losses of natural floodplain functions, including floodwater storage and conveyance, as well as changes in sediment transport processes. The reduction or elimination of riparian and floodplain habitats produced catastrophic consequences for native salmonid populations. Channelization of rivers and streams led to an increase in erosive water velocities. Dams and other channel changes altered the natural hydrology and disrupted the flow of sediment and wood through river and stream systems. What were formerly hydraulically complex systems of braided and meandering channels and wide floodplains became high-energy, single-thread channels, sometimes in a matter of years.

At present, intensive residential, commercial, and industrial land uses occupy most of the floodplains in the lower reaches of King County's rivers and streams (land uses in the county are illustrated in **Figure 2.1-1**). In turn, floodplain management must grapple with the conflicts presented by development and the costs associated with mitigating risk to developed areas.

King County is home to six major river systems—the South Fork Skykomish, Snoqualmie, Sammamish, Cedar, Green/Duwamish, and White rivers. Using Washington's Water Resource Inventory Area (WRIA) framework, these rivers fall within four WRIAs: WRIA 7 (Snohomish River basin, which includes the South Fork Skykomish and Snoqualmie rivers), WRIA 8 (Lake Washington/Cedar/Sammamish watershed, which includes the Sammamish and Cedar rivers), WRIA 9 (Green/Duwamish and Central Puget Sound watershed, which includes Vashon-Maury Island), and WRIA 10 (Puyallup-White watershed). The watersheds and subbasins are illustrated in **Figure 2.1-2** and **Figure 2.1-3**, respectively.

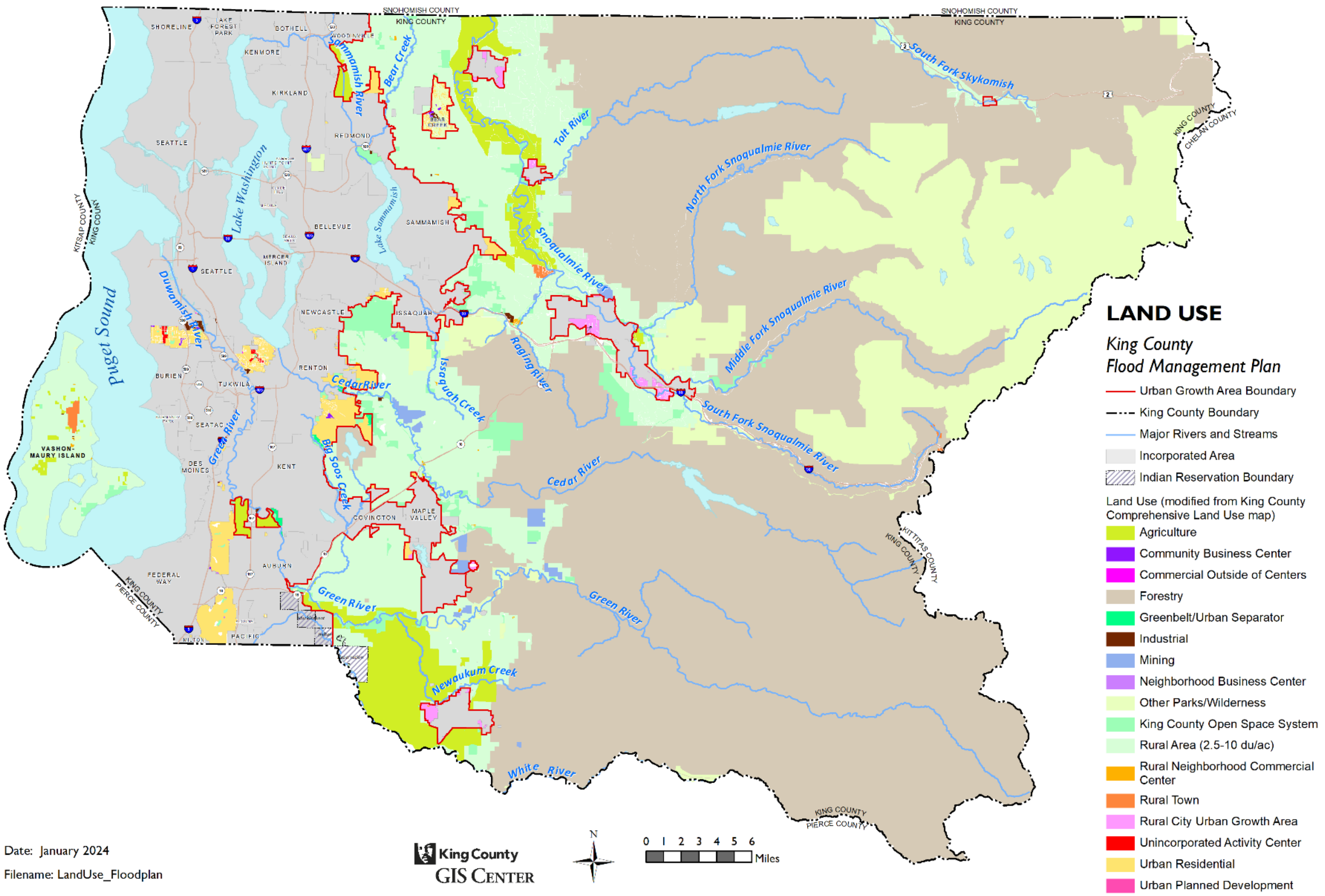


Figure 2.1-1
Land Use in King County

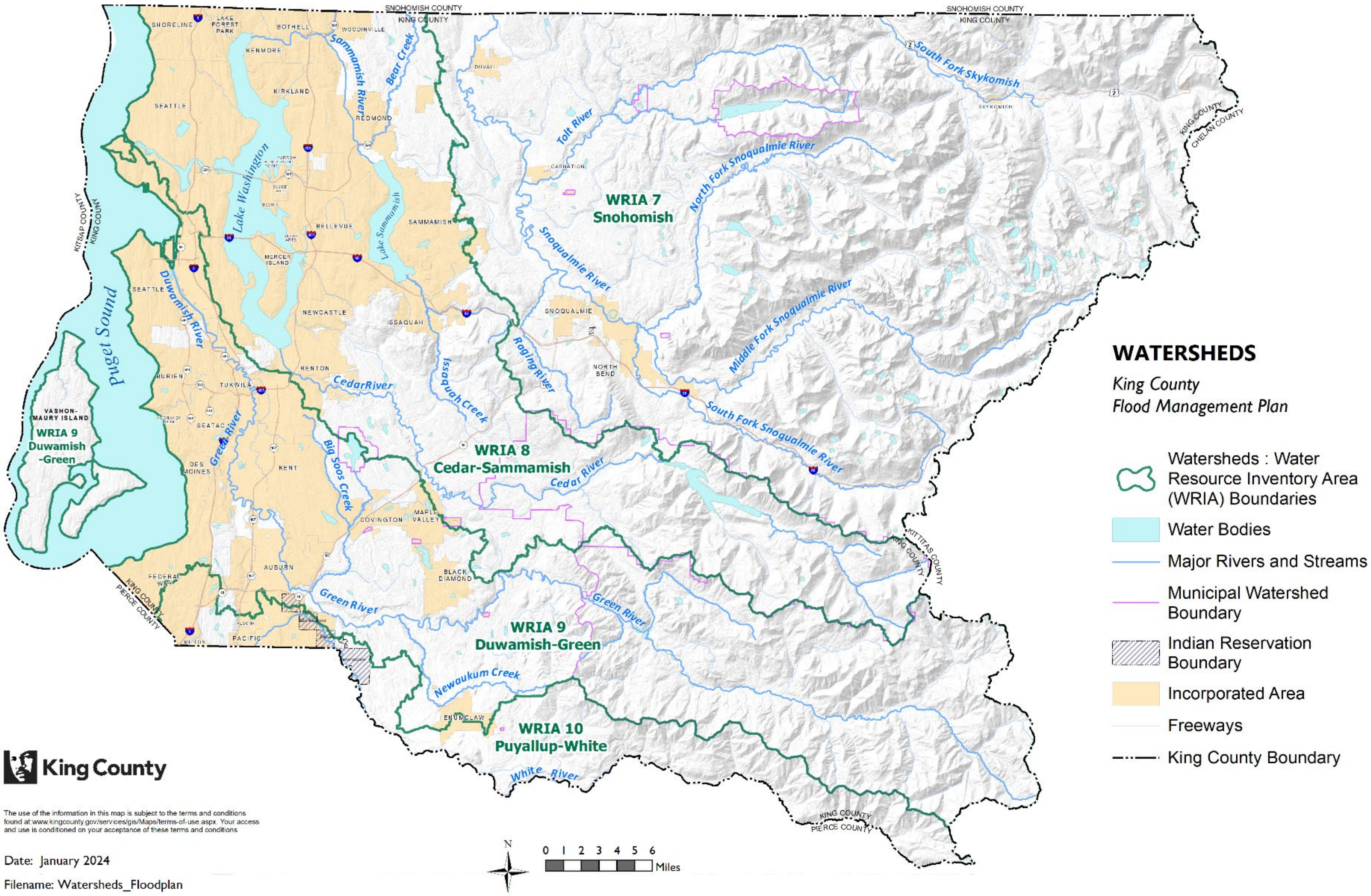


Figure 2.1-2
King County Watersheds

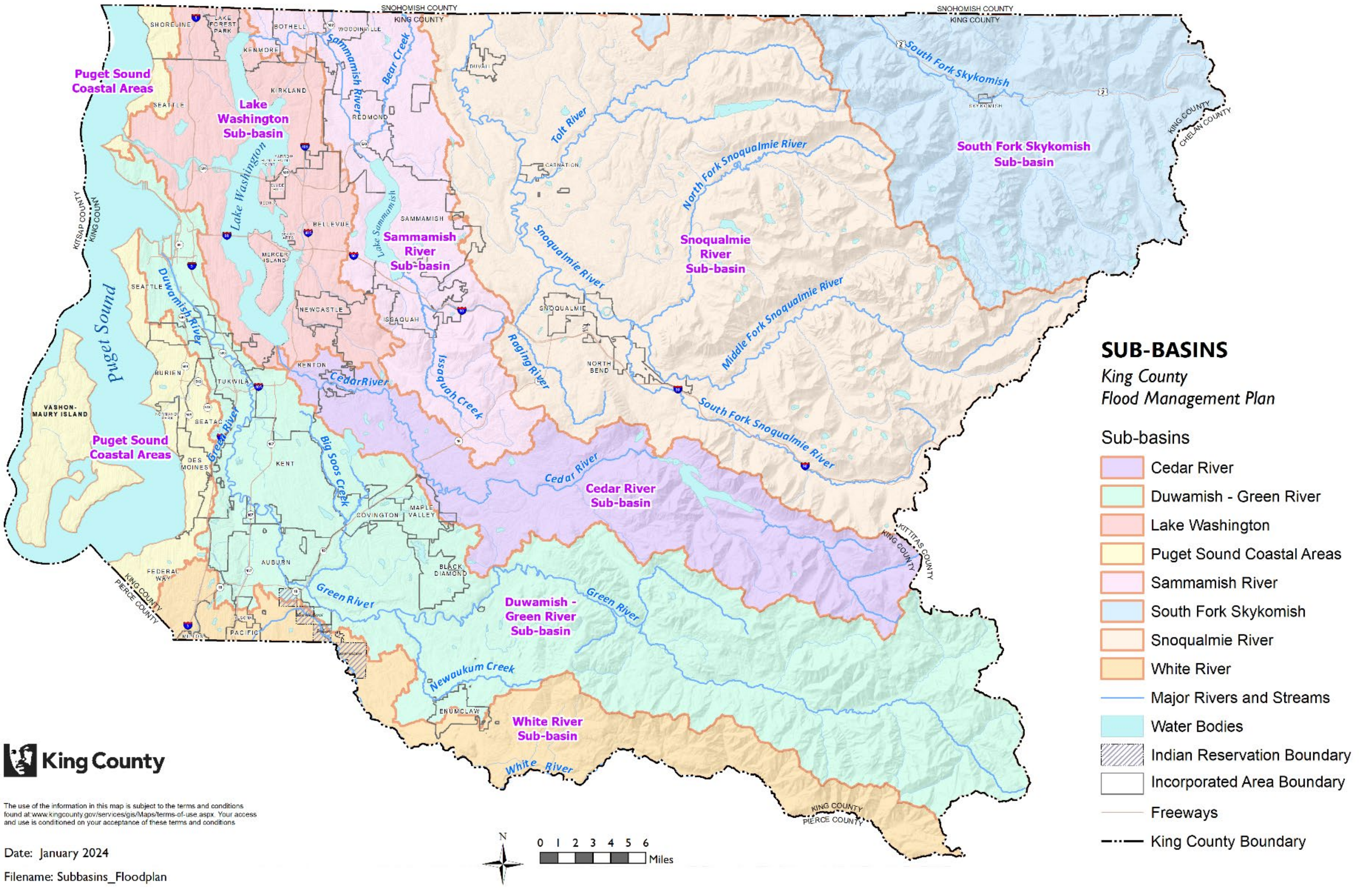


Figure 2.1-3
King County Subbasins

The character of each of the watersheds presented in Figure 2.1-2 is quite different, as summarized below (more extensive discussion of each basin's characteristics is provided in Sections 2.2 through 2.5 of this plan).

- **South Fork Skykomish/Snoqualmie River Watershed –** The Snoqualmie River and the South Fork Skykomish River, in the northeast portion of King County, are part of the larger Snohomish River watershed. The Snoqualmie River Valley is the most flood-prone area of King County, and flooding typically results in inundation by deep, slow-moving floodwaters, with some areas of deep and fast flows, especially along certain tributaries. The placename "Snoqualmie" is used in many places within this plan. The term takes its name from the sdukʷalbixʷ, Snoqualmie People, who have lived in these lands since time immemorial. The South Fork Skykomish River generates deep, fast-moving flood flows capable of severe bank erosion.
- **Lake Washington/Cedar/Sammamish River Watershed –** The Lake Washington/Cedar/Sammamish watershed has two rivers—the Cedar and Sammamish—which connect to Puget Sound via a lake and a manmade system of channels, including the Hiram Chittenden (Ballard) Locks. The Cedar River experiences fast, erosive flows, whereas the Sammamish River experiences very little overbank flooding. Flooding occurs in other areas of the watershed, including "flashy" flows along Issaquah Creek and other urban streams and elevated water levels along the shoreline of Lake Sammamish. ("Flashy" hydrology refers to floodwater flows that can rise quickly during storms with minimal infiltration.)
- **Green/Duwamish River Watershed –** The Green River becomes the Duwamish River at the Black River confluence (River Mile 11.0). Flooding along the Green River can be fast flow in areas and slow-moving overbank inundation in others. The Duwamish River is characterized primarily by slow-moving inundation. The Howard Hanson Dam in the upper reaches of the Green River, built and managed by the U.S. Army Corps of Engineers (Corps), provides flood control to the highly developed downstream areas of the river corridor. Flooding on the Green River is primarily precipitation-driven, and the Duwamish River in the lower watershed faces compound flood risk arising from precipitation and tidal influence.
- **White River Watershed –** The White River in King County is lightly populated through much of its length. The river flows through the Muckleshoot Indian Tribe reservation before reaching more developed areas in the most downstream part of the river. These developed areas face significant flood risk due to being in a depositional reach of the river. The river carries the most significant sediment load of any river in King County, and reduced channel capacity arising from ongoing sediment deposition is a primary flood risk in this watershed.

Tributary Flooding

A tributary is a smaller stream or river that flows into a larger river; for example, Tokul Creek flows into the Snoqualmie River and is therefore a tributary of the Snoqualmie. King County has an extensive network of smaller tributary streams. Some of these are tributaries to the mainstem rivers described above, some flow into lakes (such as Lake Washington and Lake Sammamish), and some flow directly from their point of origin into Puget Sound. Despite their smaller size than rivers, tributaries experience flooding that can affect King County communities in significant ways.

Erosion from tributary flooding on Issaquah Creek, January 2021

Tributary flooding can be similar in character to riverine flooding; overbank flows and channel migration result in impacts that resemble those that occur along rivers, albeit on a smaller scale. Like larger rivers, tributaries have been modified by humans in ways that can exacerbate flooding. Streams have been rerouted, piped, straightened, dredged, armored, and otherwise changed in ways that limit the natural ability of the stream to convey large volumes of water. In addition to being disconnected from their floodplains, wetland habitats that served as reservoirs for higher flows have been lost or highly modified in many locations.

Tributaries are especially sensitive to changing precipitation patterns. Due to their smaller size, they typically have less capacity to handle extreme rainfall or increased runoff from impervious surfaces. They also can transport and deposit sediment in ways that exacerbate localized flooding problems or present risk in new or unexpected ways. One such way this occurs is through alluvial fans, which typically form accumulations of sediment at the base of steeper slopes. These features can displace water and cause flooding in areas that may not have previously been known to experience flooding. Streams on alluvial fans can experience seasonal or year-round flows, landslides and debris flows, avulsions, and flooding from beaver dam outbursts. This is recognized as a unique type of flood hazard in certain King County communities. As precipitation events become more extreme with climate change, and with increased development that creates more impervious surfaces, flood risk associated with tributaries will continue to be a problem in King County.

Coastal Flooding

King County has 103 miles of saltwater shoreline, including incorporated areas along the east side of Puget Sound and the unincorporated areas of Vashon and Maury islands. Coastal flooding results when high tides and storm surges inundate or cause damaging erosion to normally dry areas along the marine shoreline (FEMA 2023). An additional factor affecting King County communities is referred to as compound flooding, which is when high tides, storm surges, and inland factors—such as saturated soils and large volumes of freshwater inflow—combine to exacerbate flooding conditions.

Coastal flooding and coastal erosion are not new phenomena in King County, but mitigating coastal flood risk has, historically, not been a focus of King County's flood risk reduction program. King County has mapped a coastal high-hazard area and has regulations in place to guide allowable activities within this area, but the County has only sporadically implemented other coastal flood risk mitigation activities.

In addition to the current coastal flood risk, sea level rise has profound implications for future risk along marine shorelines, especially those that are highly developed. King County has identified a sea level rise risk area for the Vashon and Maury Island shorelines and developed accompanying regulations. The scientific knowledge about sea level rise continues to evolve, and King County and cities within the county need to prepare now to address what will very likely be increasing flood risk in coastal areas.

Although rare, tsunami inundation of Puget Sound coastal areas is another type of coastal flood hazard. Research indicates that a rupture along the Seattle Fault Zone resulted in a tsunami along the coast at the West Point Wastewater Treatment Plant. A similar event could inundate Puget Sound coastlines and portions of the Duwamish River shoreline.

Waterfront road flooding on Maury Island, December 2022

Urban Flooding

Flooding in urban areas may result from rivers, smaller streams, and coastal factors, but for the purposes of this Flood Plan, urban flooding refers to flooding caused by stormwater runoff or flooding resulting from overwhelmed urban storm sewer systems.

Extensive development in the urban areas of King County, coupled with aging infrastructure and climate change, make urban flooding an especially challenging problem. While flood hazard areas of some waterbodies in urban areas are delineated and regulated, flood hazards associated with flooding from runoff and overwhelmed stormwater infrastructure are not delineated or regulated. Predicting where and when urban flooding will occur is exceedingly difficult due to the number of intersecting factors that drive the problem. Also, since water does not follow jurisdictional boundaries, overlapping authorities can make mitigation of urban flooding issues difficult, although stormwater regulations under the Clean Water Act provide some consistency across jurisdictions.

Urban flooding in South Park neighborhood of Seattle, December 2022

Natural and Beneficial Functions of Flooding

The remaining sections of this chapter provide an overview of conditions across King County's major watersheds and other flood hazard areas, but some of the beneficial functions of flooding are the same regardless of location.

Periodic flooding helps to create river floodplains that contain unique and productive habitats. Because of floods and movement of river channels, floodplains are highly dynamic, and the ecosystems within them are adapted to and dependent on periodic inundation. For example, some riparian plants depend on floods for seed dispersal and establishment, and many bird and fish species rely on annual inundation of floodplain habitats for foraging and growth.

In areas where floodplains and watercourses remain connected or have been reconnected, periodic floods help to create and maintain channel networks, floodplain wetlands, and off-channel habitats, such as side channels, backwaters, and ponds. All these habitat types are especially important for juvenile salmonids (including those listed as threatened under the ESA). Floods can provide organisms (such as fish and birds) with access to productive floodplain habitat and connectivity between aquatic, riparian, floodplain, and wetland habitats, which are again crucial for species like salmon (juvenile salmon, in particular) that depend on these habitats for growth. Connected floodplains also provide areas of refuge for juvenile salmon, where they can escape the high velocity of the main channel until the flood levels subside.

Floods can also move materials that are natural building blocks for salmon habitat. High flows can deliver nutrients to floodplain habitats, increasing ecological productivity. Flooding can recruit and transport large wood within river and stream channels, which supports the complex habitat needed for fish and other aquatic organisms. Flooding also moves sediment in ways that are beneficial to fish habitat, including delivery of spawning gravels to waterways through bank erosion, transporting gravel from upstream, or depositing material in locations that connect riverine and floodplain habitat. High flows during flooding can drive scour and erosion around large wood, log jams, and riverbanks, creating pools and diverse habitat. Sediment transport during floods can also help build and maintain estuary habitats (in systems with intact estuaries). These biodiversity hot spots are critical rearing habitat for juvenile Chinook salmon.

In addition to the beneficial functions of flooding itself, the floodplains created by periodic flooding provide additional advantages. Naturally vegetated and connected floodplain ecosystems in which artificial drainage networks have been removed can slow and store floodwaters and disperse energy, reducing flood stages and erosion potential. Healthy floodplain vegetation and soil microbes can improve water quality by removing pollutants and excess sediment or nutrients from runoff or river water, and stream bank vegetation can resist erosion. Connected and naturally drained floodplains can increase connections with groundwater and can supplement stream base flows in dry times of year. Floodplains can also store sediment and reduce the rates of sediment transport downstream.

Climate Change

As noted in King County's 2020 Strategic Climate Action Plan, the effects of climate change are already being felt in the county. Since 1900, average annual air temperature in the Puget Sound region has increased 1.3 degrees Fahrenheit. Heavy rain events are getting heavier, the region is experiencing a long-term decline in snow and ice in the Cascades and Olympic mountains, and sea level has risen more than 9 inches in Seattle since 1899.

Climate change is projected to increase the potential for river and coastal flooding in King County. While results will vary by location and flood interval, river flooding is expected to increase due to the combined effects of wetter winters, more intense heavy rain events, and more winter precipitation falling as rain rather than snow in mountain watersheds. The potential effects of these factors on flooding conditions in each of the county's WRIAs and other environmental contexts are detailed in Sections 2.2 through 2.6. In addition to changes in flooding conditions, climate change will likely also produce negative effects for native salmon populations.

Sea level rise will also increase the frequency and extent of coastal flooding. Sea level in King County is projected to rise approximately 1 to 2 feet by mid-century and 2 to 5 feet by 2100 under a high greenhouse gas scenario. This expected increase may also exacerbate compound flooding in coastal drainages, as noted above in the section on coastal flooding.

Tribal Context

King County has a large and diverse population of indigenous people who contribute a unique history, strength, and vibrancy to the community. Since time immemorial, Coast Salish speaking people cared for the lands of the Salish Sea basin. They developed culture, stewarded land and water, and established communities. As the United States expanded its borders and Washington achieved statehood, federal and state actions forced indigenous people to relinquish their ancestral homelands and relocate to consolidated reservations. These forced actions threatened the relationship indigenous people had with the land, causing harm to native cultures and tribes. Coast Salish descendants and other indigenous people have endured, however, and have revitalized indigenous peoples' relationship with the land and Coast Salish peoples' relationship with this place.

Approximately 22,697 King County residents self-identify as American Indian / Alaska Native. Of that demographic group, 3,900 residents are members of local Indian tribes who are indigenous to this place. King County routinely interacts with six indigenous tribal organizations, including: Duwamish Tribal Services, Muckleshoot Tribe, Puyallup Tribe, Snoqualmie Tribe, Suquamish Tribe, and Tulalip Tribes. Tribal reservations in King County are illustrated on **Figure 2.1-4**.

Five of these tribal organizations, including Muckleshoot, Puyallup, Snoqualmie, Suquamish, and Tulalip, have been formally recognized by the United States as Indian tribes. Pursuant to such recognition, each of these tribes has established a constitutional form of government and corporate form of business. King County has a government-to-government relationship with these five Indian tribes premised on their sovereign right to self-governance.

Four of these tribal organizations, including Muckleshoot, Puyallup, Suquamish, and Tulalip, have been adjudicated to be the successors in interest to tribal people who signed the Treaties of Medicine Creek and/or Point Elliott. Federal courts have concluded that these tribes used and occupied land and marine territory throughout what is now King County and retain rights to fish, hunt, gather, and travel to and from certain of their traditional harvest areas. As treaty tribes, Muckleshoot, Puyallup, Suquamish, and Tulalip Tribes are co-managers with the State of Washington regarding fish and wildlife and related habitat.

Two of these tribal organizations, including Muckleshoot and Snoqualmie, have federally protected reservations located in King County. Three others, including Puyallup, Suquamish, and Tulalip, also have reservations located in adjacent counties.

King County routinely consults with all five of the local federally recognized tribes, including Muckleshoot, Puyallup, Snoqualmie, Suquamish, and Tulalip, and the County will also occasionally confer with Duwamish Tribal Services, a tribal organization that is not a federally recognized Indian tribal government.

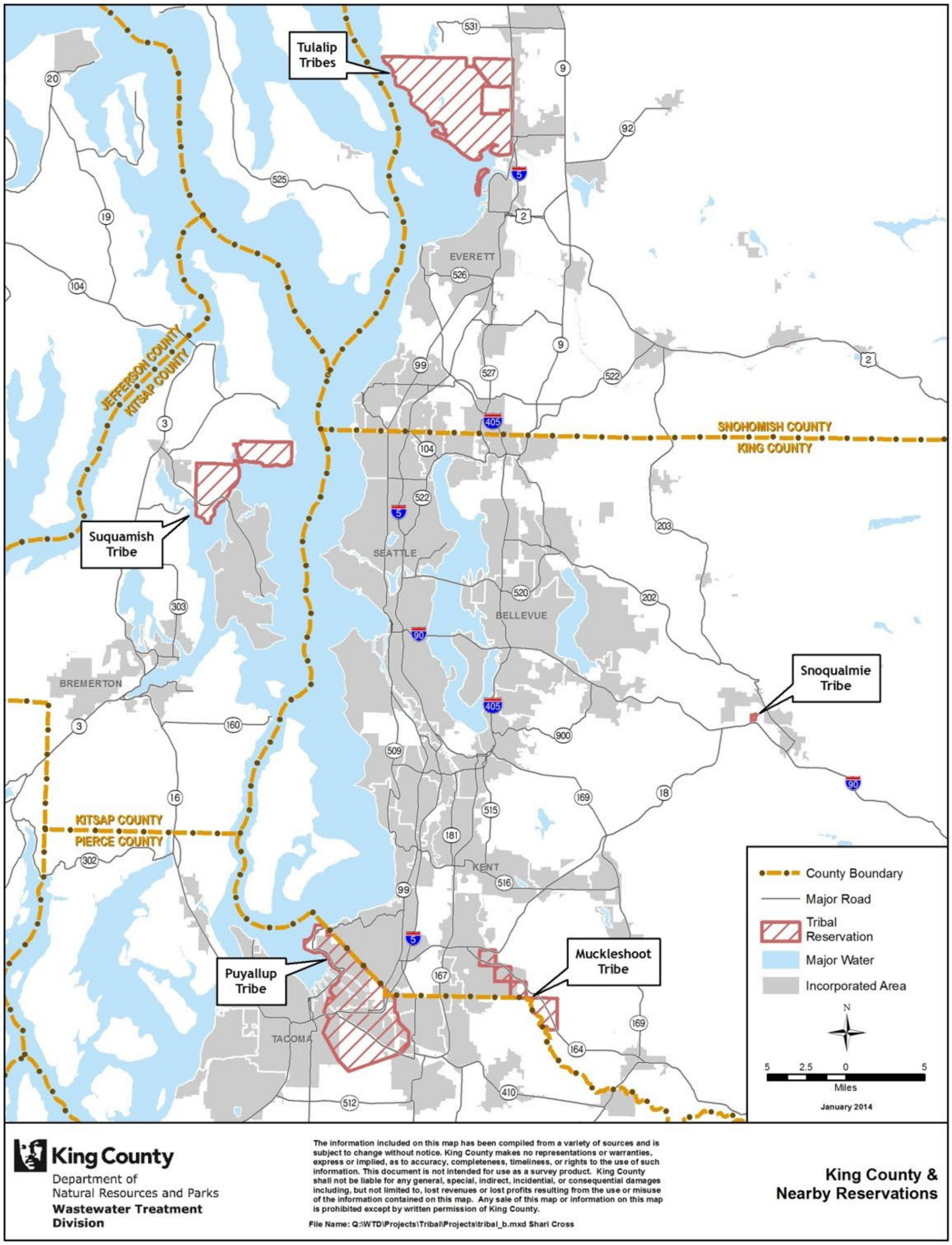


Figure 2.1-4
Tribal Reservations in King County

Demographics and Social Vulnerability of King County Flood Hazard Areas

Factors such as race, age, gender, educational attainment, health, economic status, and housing status are elements that collectively influence “social vulnerability.” The concept of social vulnerability relates to how risks are experienced and provides an avenue to understand risk beyond that which arises from physical hazards. Acknowledging social vulnerability reflects the reality that certain groups may experience and recover from disasters differently than others and is a first step toward identifying strategies to build flood resilience among the most vulnerable communities.

The Centers for Disease Control created the Social Vulnerability Index (SVI), which is a tool to help understand the social vulnerability of every census tract in the United States.[1] Understanding social vulnerability through the SVI can help local governments identify communities that will most likely need support before, during, and after a hazardous event. King County assembled SVI information for subbasins in flood hazard areas, as shown in **Figure 2.1-5**. The SVI uses a 0–1 scale, where higher numbers indicate greater levels of social vulnerability. The flood hazard areas demonstrating the highest vulnerability using the SVI are the lower Cedar River in Renton, the lower White River, and the lower Green/Duwamish River.

King County conducted a demographic analysis to support the development of this Flood Plan, which identified 57,737 people living in areas with known flood hazards, including those along the marine shoreline and on small coastal creeks that drain into Puget Sound. Of the 57,737 residents living in mapped flood hazard areas, approximately 41 percent are black, indigenous, and people of color (BIPOC). The Green/Duwamish watershed is the only major river watershed in King County in which more BIPOC residents (59 percent) than white residents (41 percent) reside in mapped flood hazard areas, largely due to the high percentage of BIPOC (63 percent) and large population (13,800) residing in the lower Green/Duwamish River subbasin. Other watersheds exhibiting a high percentage of BIPOC community members residing in flood hazard areas include the Sammamish (43 percent), Cedar (36 percent), and White River watersheds (38 percent).

1 More information available at: https://www.atsdr.cdc.gov/placeandhealth/svi/index.html.

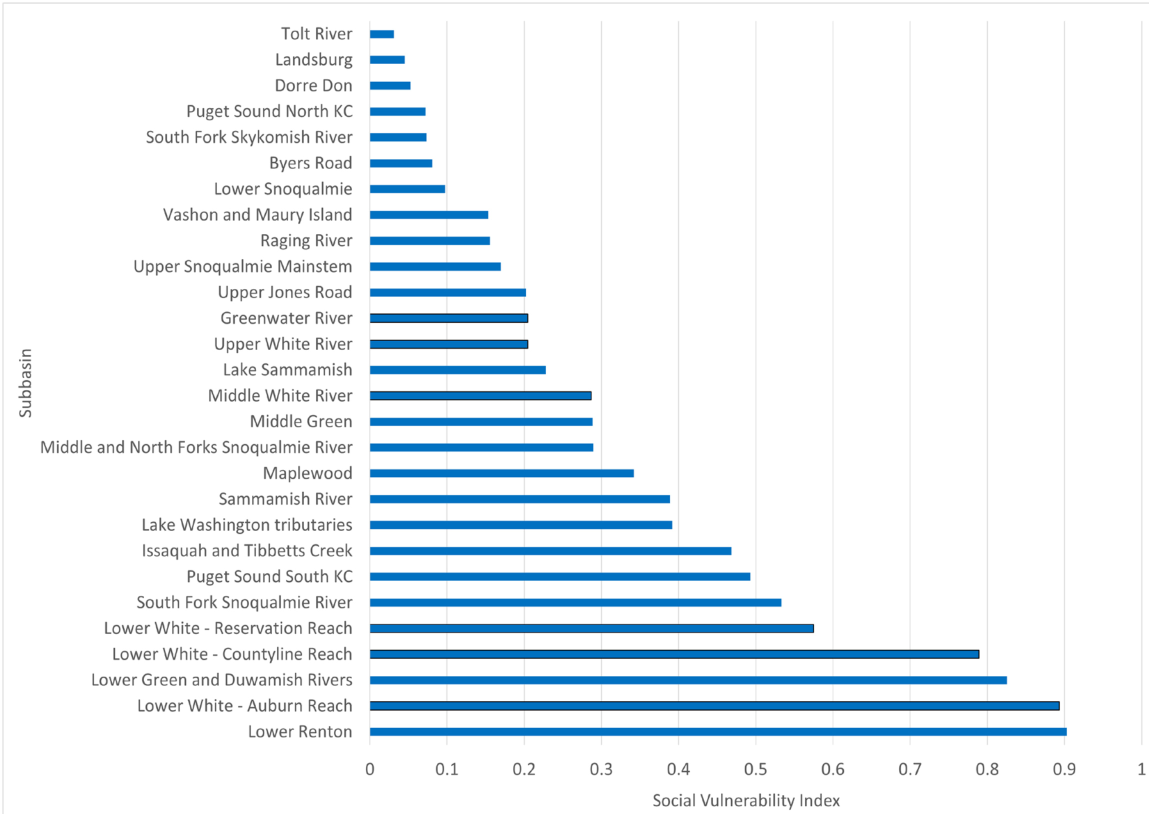


Figure 2.1-5
Social Vulnerability Index Scores for Flood Hazard Area Subbasins

Approximately 47 percent of King County's total population is BIPOC, and, as noted above, BIPOC communities comprise 41 percent of those living in the county's flood hazard areas. For the BIPOC population living in the county's flood hazard areas, racial demographics are as follows (and as illustrated in **Figure 2.1-6**):

- Asian – 13 percent
- Hispanic or Latino – 13 percent
- Black – 5 percent
- American Indian or Alaska Native – 1 percent
- Hawaiian or other Pacific Islander – 1 percent
- Two or more races – 7 percent
- Other race – 1 percent

Interestingly, each of these percentages is lower than the racial percentages for the King County population as a whole, with the exception of Hispanic or Latino. Those identifying as Hispanic or Latino comprise approximately 10.5 percent of King County's total population, yet 13 percent of those living in the county's flood hazard areas identify as Hispanic or Latino.

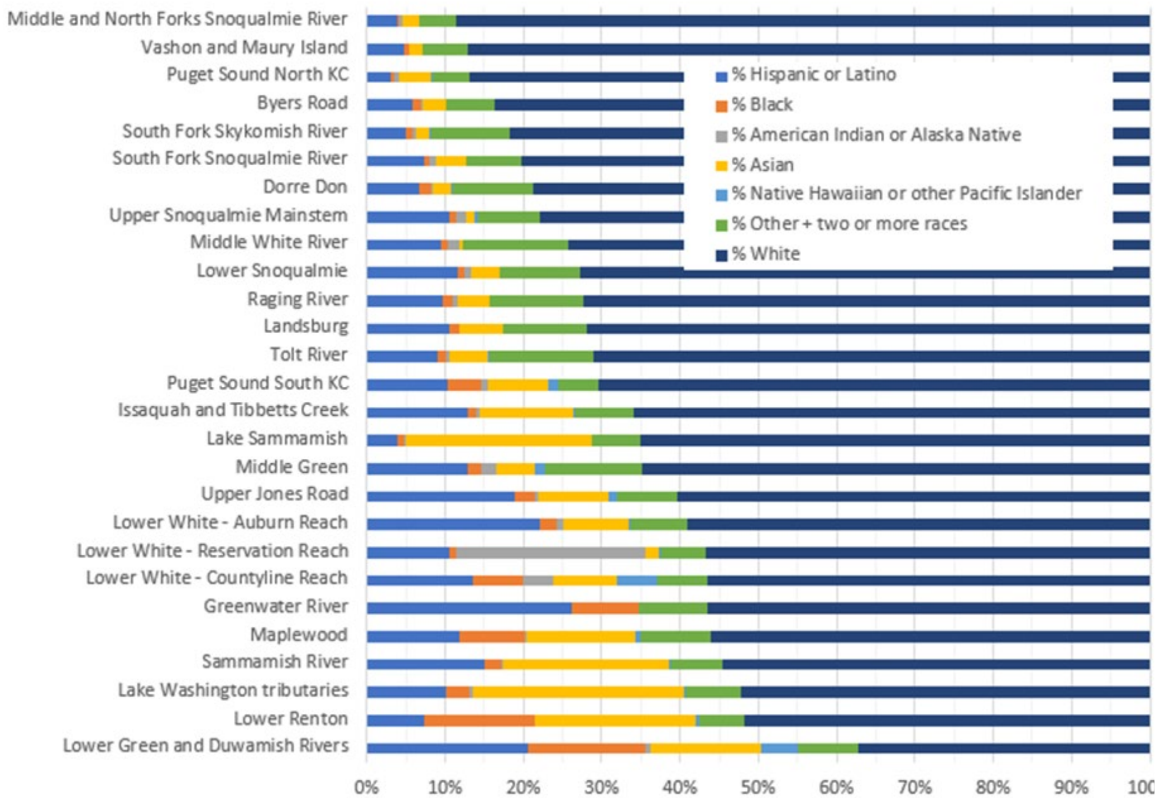


Figure 2.1-6
Racial Distribution of Populations in King County Flood Hazard Areas, by Subbasin

By applying the SVI concept, demographic data can be used to estimate a population's relative vulnerability to better understand who will be impacted by or benefit from floodplain management activities. The data can help to identify communities that might have the greatest relative social vulnerability and can suggest needs that may inform overarching strategies for engaging or planning with those communities. Broad race categories, however, do not reflect the diversity of nationalities, cultures, and perspectives represented. In addition, while some people may share demographic characteristics, that does not mean they have the same needs. These data are a starting point for understanding who lives throughout King County's flood hazard areas and should not replace more direct interaction and outreach to better understand the people served by the County.

Potential Risk and Damages from Flooding

While developing this Flood Plan, King County performed a flood risk assessment using FEMA's Hazus Risk Assessment Platform (Version 6.0). The purpose of this assessment was to identify the number of structures exposed to flood events of different magnitudes and to estimate the potential dollar value of damages associated with those events. The assessment evaluated the risk associated with the 10, 5, 2, 1, and 0.2 percent annual chance flood events.

Results were generated for general building stock (all structures), critical facilities,[2] and repetitive loss properties. Flood hazard areas are illustrated in **Figure 2.1-7**, critical facilities are mapped in **Figure 2.1-8**, channel migration zones[3] are mapped in **Figure 2.1-9**, repetitive loss areas are mapped in **Figure 2.1-10**, and landslide hazard areas are mapped in **Figure 2.1-11**.

Results from the flood hazard risk assessment are further explained in each of the remaining sections of this chapter (Sections 2.2 through 2.6), accompanying the relevant geography to which they apply, and Section 2.7 presents countywide results. Briefly introducing the county-level information here, the risk assessment identified the following:

- Across King County, 13,987 structures (not including critical facilities) could be exposed to a 0.2 percent annual chance riverine flood event, and 1,161 structures could be exposed to a 0.2 percent annual chance coastal flood event.
- While flood events do not occur uniformly across the landscape, the assessment estimated that potential damages from a 0.2 percent annual chance riverine flood event could exceed $1.2 billion countywide. Potential damages from a 0.2 percent annual chance coastal flood event could exceed $125 million.
- In total, 574 critical facilities could be exposed to the 0.2 percent annual chance riverine flood event, and 27 critical facilities could be exposed to the 0.2 percent annual chance coastal flood event. Potential damages could reach $136 million for a 0.2 percent annual chance riverine flood event and $335,000 for a 0.2 percent annual chance coastal flood event.

Chapter Organization

The following sections of this chapter share insights about flooding characteristics, flooding problems, and other attributes of flood hazard areas in King County, organized by watershed or WRIA listed above. Areas included in the flooding overview include risk associated with special flood hazard areas, repetitive loss areas, areas not mapped as special flood hazard areas but that have flooded in the past, and other known surface flooding issues. Additionally, this chapter and other portions of the Flood Plan contain information on less-frequent events that contribute to flood risk, as well as flood problems that may get worse in the future because of the effects of climate change or changes in land use and development.

[2] For this analysis, King County defined critical facilities as those structures or facilities identified by FEMA as "community lifelines," which FEMA defines as *"enabl[ing] the continuous operation of critical government and business functions and [are] essential to human health and safety or economic security."* More information about community lifelines can be found at: https://www.fema.gov/emergency-managers/practitioners/lifelines.

[3] The channel migration zone, or CMZ, is the area within the lateral extent of likely stream channel movement that is subject to risk due to stream bank destabilization, rapid stream incision, stream bank erosion, and shifts in the location of stream channels.

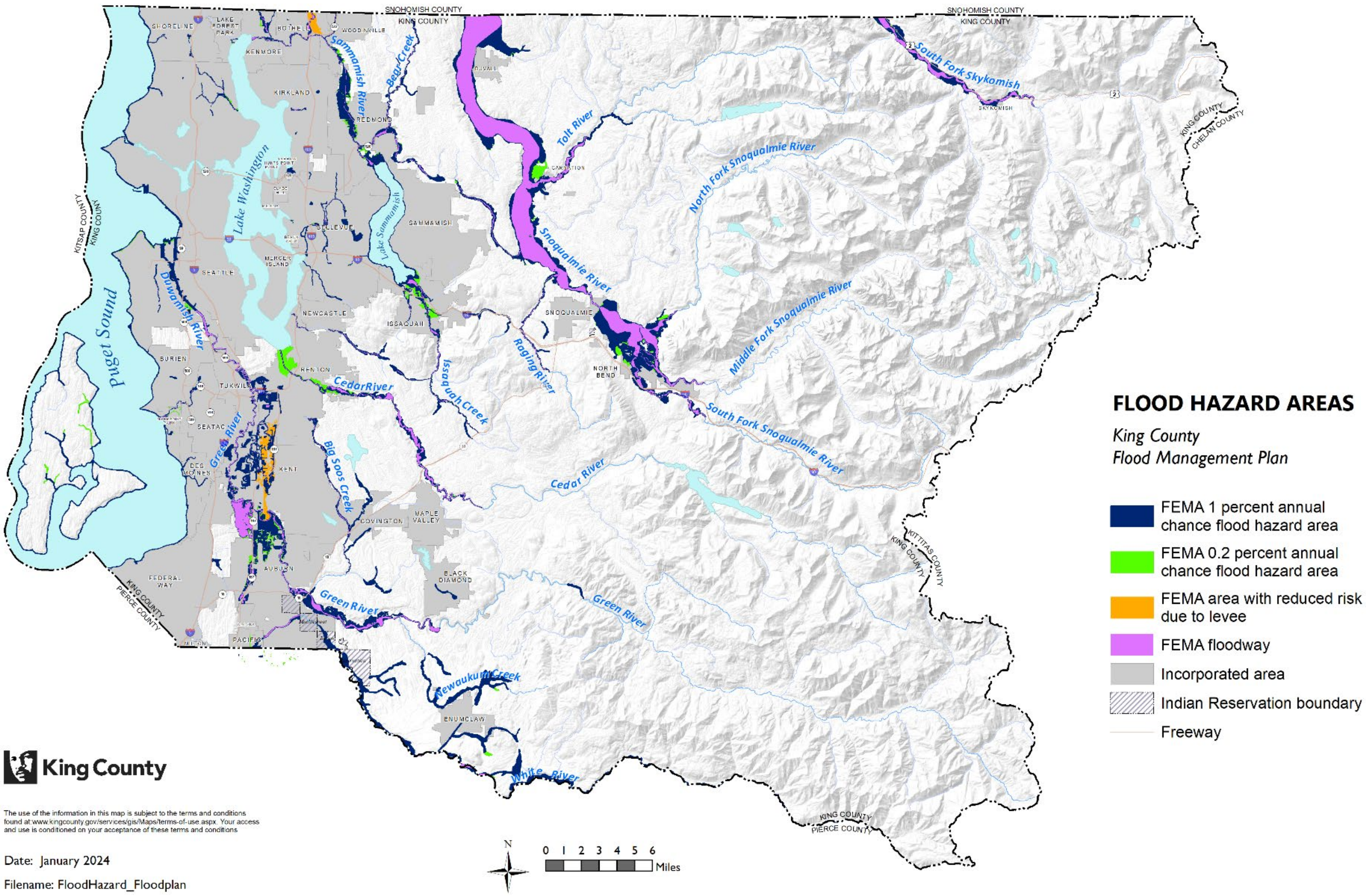
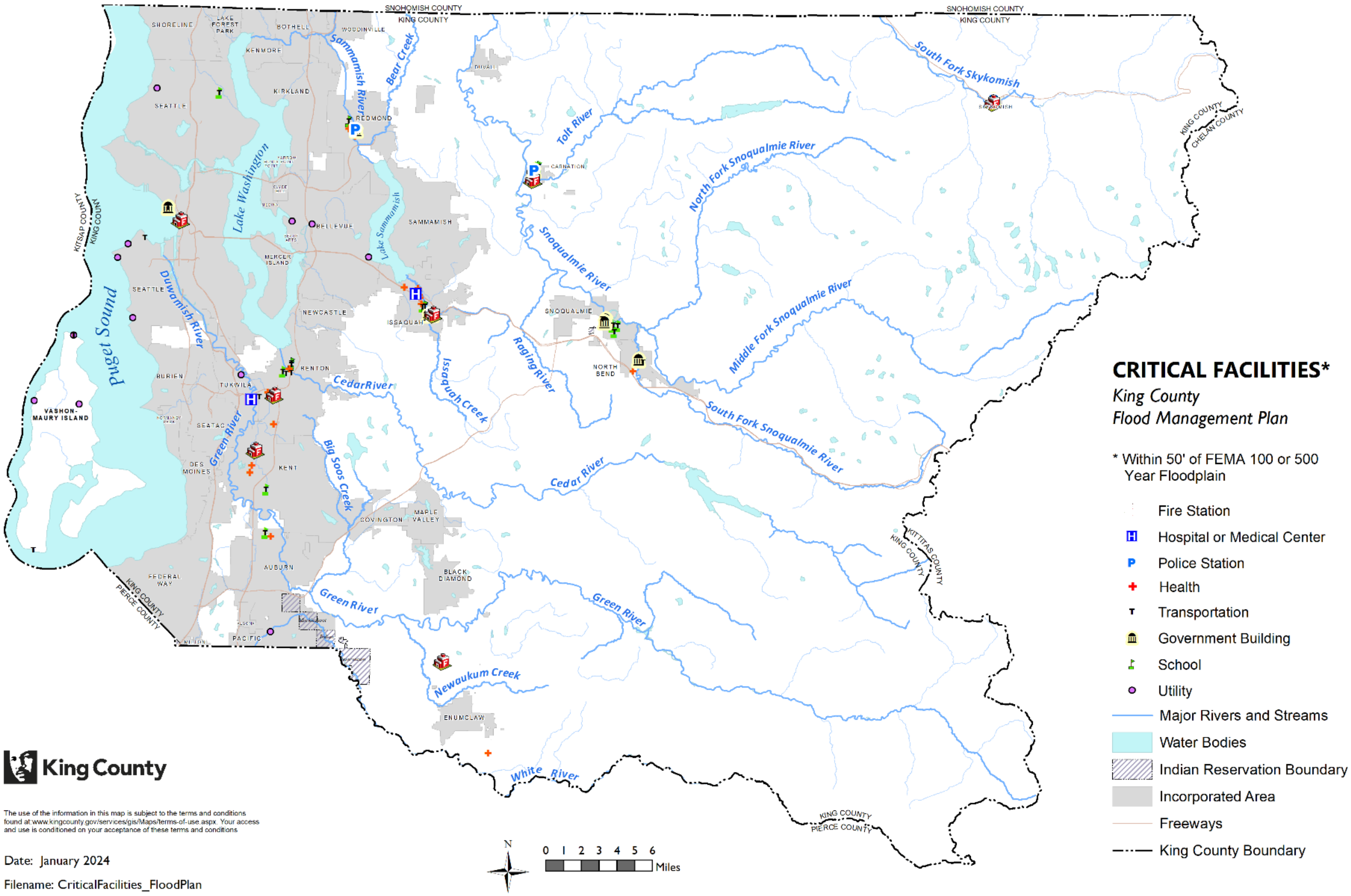


Figure 2.1-7
Flood Hazard Areas in King County



King County

Date: January 2024

Filename: CriticalFacilities_FloodPlan

Figure 2.1-8
Critical Facilities in King County

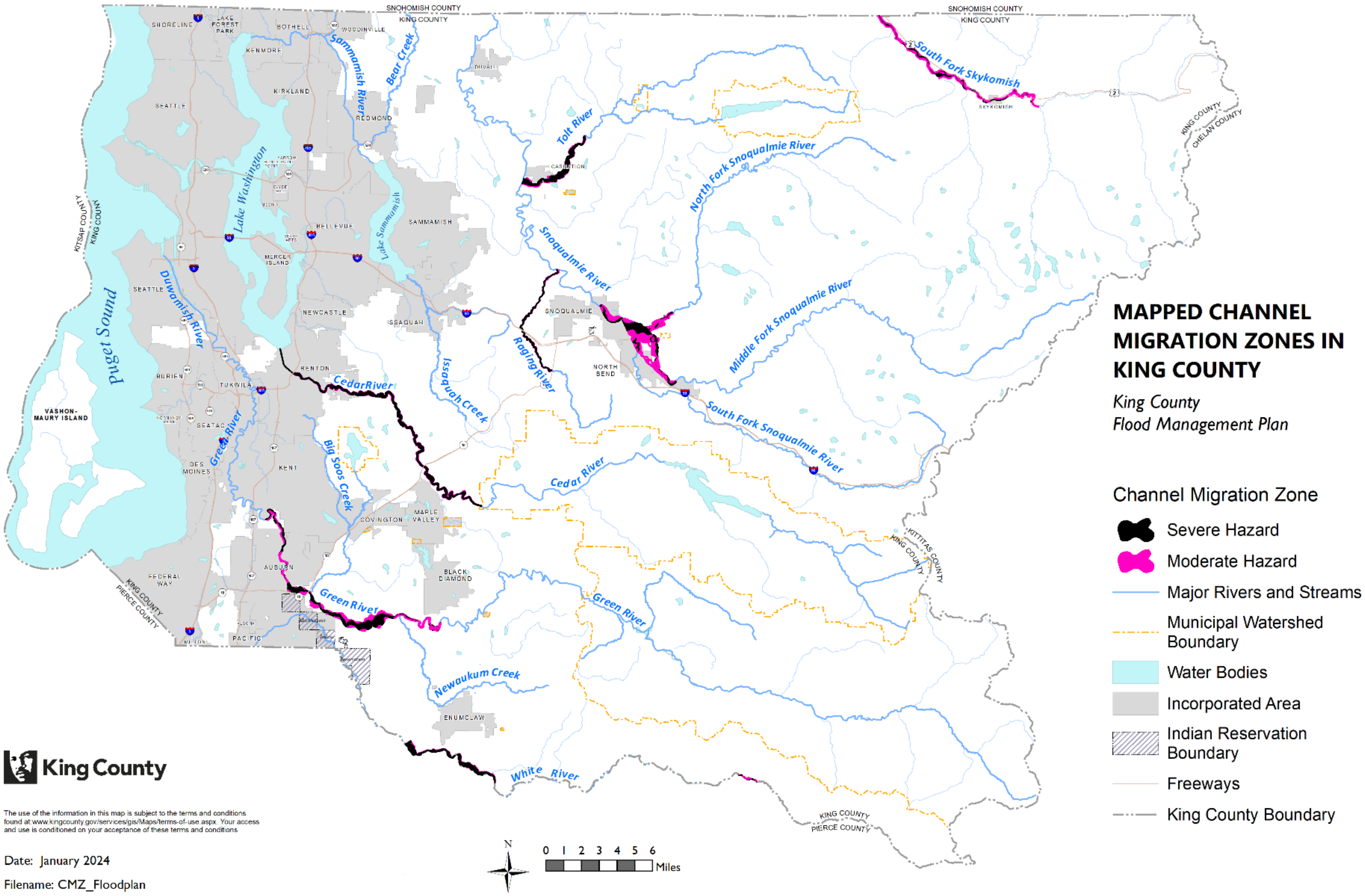


Figure 2.1-9
Channel Migration Zones in King County

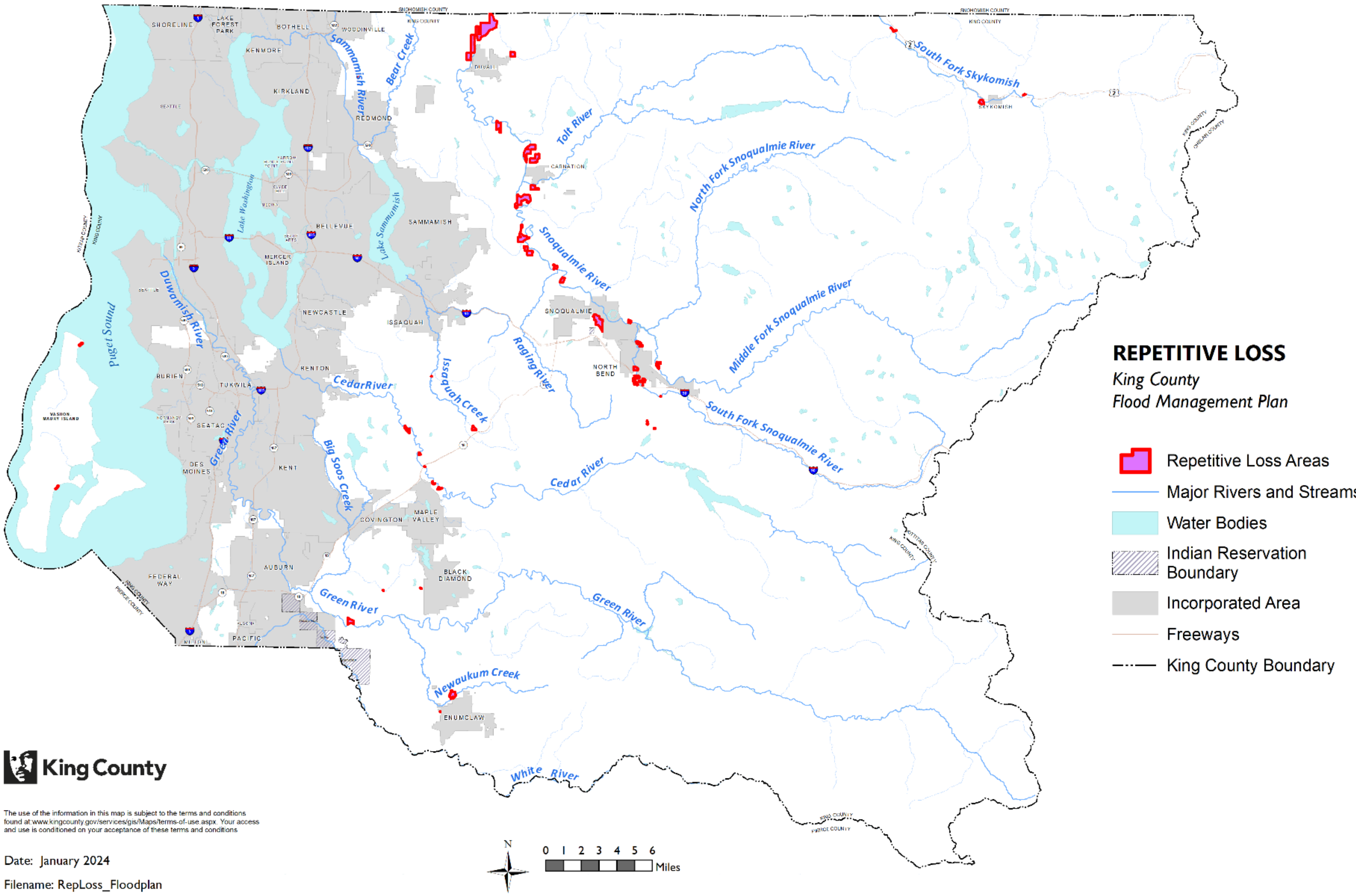


Figure 2.1-10
Repetitive Loss in King County

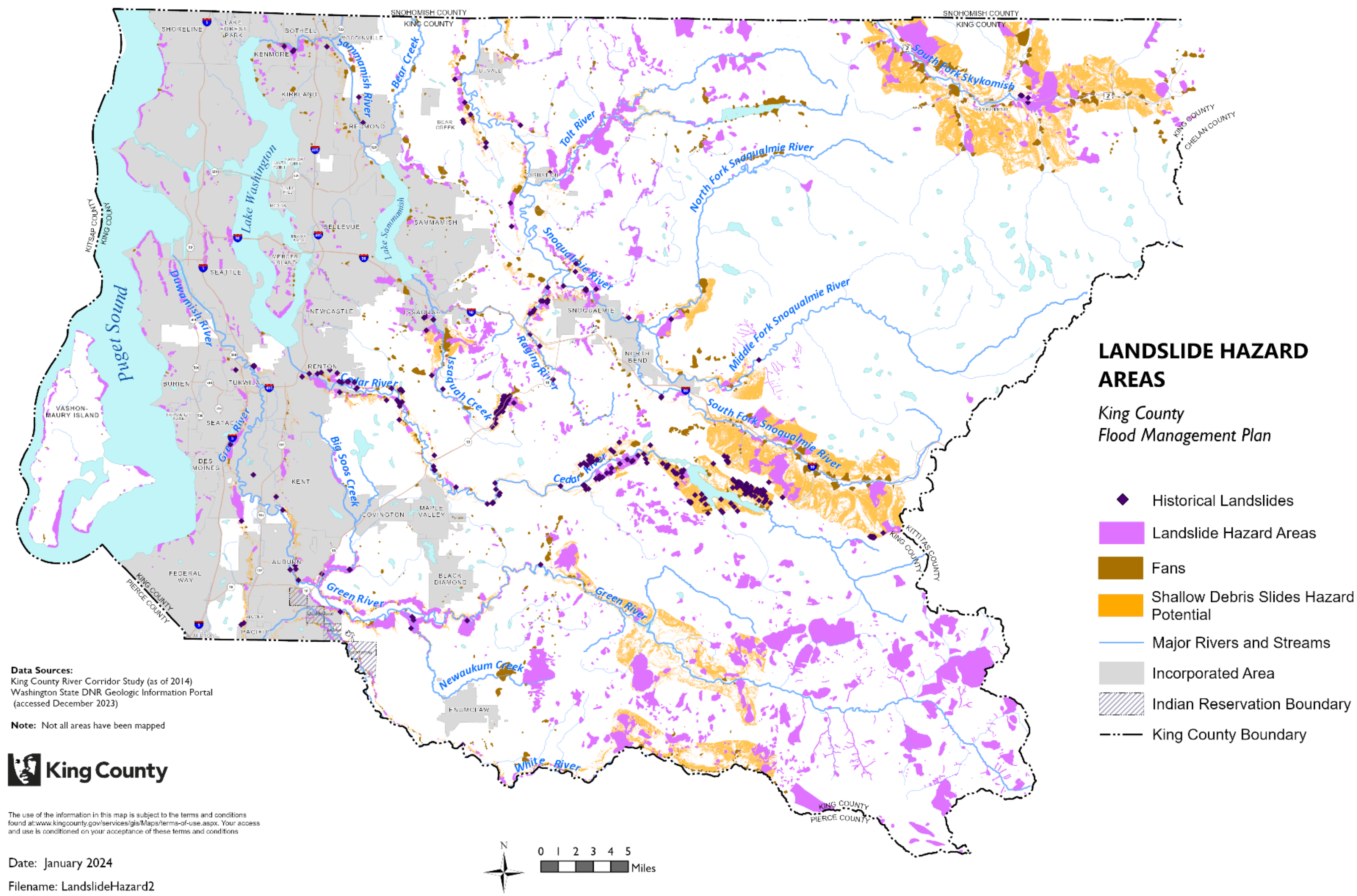


Figure 2.1-11
Landslide Hazard Areas in King County

2.2 South Fork Skykomish/Snoqualmie Watershed

Watershed at a Glance – South Fork Skykomish/Snoqualmie Watershed

WRIA	• WRIA 7
River systems/reaches included	• South Fork Skykomish River • Upper Snoqualmie River (above Snoqualmie Falls) • Lower Snoqualmie River (below Snoqualmie Falls) • Tolt River • Raging River
Basin size	• 938 square miles
Key tributaries	• Beckler, Foss, Miller, Pratt, Taylor, and Tye rivers; Boxley, Clough, Ribary, and Kimball creeks; Tokul, Patterson, Griffin, Harris, Tuck, and Cherry creeks
Dams/major infrastructure	• Snoqualmie Falls • South Fork Tolt Dam • Several low-head hydroelectric dams
Key flood years	• 1951, 1959, 1986, 1990, 2006, 2009
Key issues in the basin	• Snoqualmie River Valley is the most flood-prone area of King County • SF Skykomish River generates deep, fast-moving flood flows capable of severe bank erosion • Flood risk to extensive agricultural production district in the Snoqualmie River basin • Community isolation due to roadway flooding
Salmonid species present	• Chinook, coho, chum, pink, sockeye, steelhead, coastal and westslope cutthroat trout, rainbow trout, bull trout, Dolly Varden, eastern brook trout, mountain whitefish
Estimated economic damage from a 1 percent annual chance flood	• $205,161,278

In the northeast portion of King County, the Snoqualmie River and a portion of the South Fork Skykomish River watersheds originate in the Cascade Mountains and are part of the larger Snohomish River watershed. The two watersheds encompass 938 square miles, and the Snoqualmie and Skykomish rivers combine north of King County to form the Snohomish River, which discharges into Puget Sound in Everett. The placename "Snoqualmie" is used throughout this section. The term takes its name from the sdukʷalbixʷ, Snoqualmie People, who have lived on these lands since time immemorial.

The Snoqualmie River is the most flood-prone watershed in King County. The Snoqualmie River watershed is typically divided into the upper and lower Snoqualmie, split by Snoqualmie Falls. These lands hold great importance to the Snoqualmie and Tulalip Tribes, such as Snoqualmie Falls for the Snoqualmie Tribe.

- The **upper Snoqualmie River** watershed includes the river's three forks (North, Middle, and South), which join upstream of the falls to become the mainstem Snoqualmie River.

The upper valley is home to the cities of North Bend and Snoqualmie, which are primarily residential and commercial centers with a mixture of development densities, and the Snoqualmie Tribe reservation and other tribal trust lands. Extensive federal and state forests and recreational areas are in the upper reaches of the basin.

- In the wide, flat **lower Snoqualmie River** Valley, land use is primarily agricultural, with residential and commercial centers in the cities of Carnation and Duvall, and unincorporated Fall City. The Tolt River and Raging River are significant tributaries located in the lower valley.
- The **South Fork Skykomish River** basin is primarily characterized by forest production and recreation on federal- and state-owned forest lands, with a residential and commercial center in the Town of Skykomish and rural residential land use in the unincorporated Town of Baring and the communities of Timberlane, Grotto, and Miller River. Residential and commercial development is limited by the narrow river valley, access and distance to more populated areas, and zoning.

Snoqualmie River flooding of State Route 202 near Fall City, November 2006

Each of the major basins is described below: South Fork Skykomish River, upper Snoqualmie River, lower Snoqualmie River, Tolt River, and Raging River.

Input on Flooding in the South Fork Skykomish/Snoqualmie

Much of the input provided about flooding in the South Fork Skykomish/Snoqualmie River watershed related to the influence of flooding on the landscape and land use of the watershed. Identified problems include impacts on agriculture and recurring and prolonged instances of deep flooding. Community members and partners noted erosion impacts on farms and roads in the basin as disruptive and damaging. One of the most-raised concerns was flooding of roadways, which presents risks to safe evacuation and limits the ability for people to reach their homes. Flooding in neighborhoods, drainage issues in developed areas, and stormwater runoff from development were cited as factors contributing to worsening flood impacts throughout the watershed. In the lower Snoqualmie Valley, community members and partners described sediment deposition causing tributaries to overtop their banks or avulse as an issue, especially in agricultural areas, and potentially exacerbated by stormwater runoff.

Overview of the South Fork Skykomish River Basin

The South Fork Skykomish River begins at the confluence of the Tye and Foss rivers, about 13 river miles upstream of the King and Snohomish county line. The river flows through the Town of Skykomish, which is located between the major tributaries of the Beckler and Miller rivers. Development is sparse in the watershed, concentrated in a few locations along the river in the Town of Skykomish; the unincorporated communities of Timberlane Village, Baring, Grotto, and Miller River; and along the lowermost reaches of the larger tributaries.

The South Fork Skykomish headwaters and tributaries are high in the Cascades, and the river has a drainage area of 120 square miles above the confluence with the North Fork (in Snohomish County). The river flows west and crosses into Snohomish County downstream of Baring. In Snohomish County, near the Town of Index, the South Fork Skykomish and the North Fork Skykomish meet to form the mainstem Skykomish River. The Skykomish River joins the Snoqualmie River to form the Snohomish River, which empties into Puget Sound in Everett (in Snohomish County).

Geology and Geomorphology

The South Fork Skykomish River drains steep and rugged mountains composed of bedrock that has been eroded and shaped by continental and alpine glaciation. The river valley walls are composed of bedrock, landslide and rockfall debris, and unconsolidated glacial sediments with shallow soil development. The river is a single-thread, meandering channel and has a moderately well-developed alluvial floodplain, but, in places, the South Fork Skykomish River and tributaries are confined within bedrock channels.

The channel is relatively steep and naturally confined compared to that of other large King County rivers, particularly from the confluence of the Foss and Tye rivers to the Town of Skykomish. The floodplain widens downstream to the county line as the gradient decreases.

Hydrology and Hydraulics

There are no dams or reservoirs on the South Fork Skykomish or its tributaries. With its steep upper basin slopes in high-elevation terrain forming the entire watershed, significant runoff can be delivered directly to the flood hazard management corridor along the South Fork Skykomish River. Precipitation at these high elevations can generate flooding from snowmelt and rain-on-snow events.

Floodplain mapping for the South Fork Skykomish River was updated in 2021, and King County submitted draft maps to FEMA for review and approval. **Table 2.2-1** lists the flow quantiles developed for the flood study update (Watershed Science & Engineering 2021). Quantiles were determined based on data from gages within the basin, with varying periods of record from 1903 to the present. The increase from the South Fork (SF) near Skykomish gage to the SF Skykomish at Skykomish gage indicates the inflow from the Beckler River, which joins the South Fork Skykomish between those locations. The increase from the SF Skykomish at Skykomish gage to the SF Skykomish near Index gage indicates the inflows from Maloney Creek, Miller River, Money Creek, and Index Creek, all of which flow into the South Fork Skykomish River between those gage locations. **Table 2.2-2** shows recent high-flow events for the SF Skykomish River at Skykomish gage to illustrate the extent of recent flooding in the subbasin.

TABLE 2.2-1
FLOW QUANTILES FOR THE SOUTH FORK SKYKOMISH RIVER AT SELECT LOCATIONS IN CUBIC FEET PER SECTION (CFS)

Percent Annual Chance Exceedance	Return Period	SF Skykomish near Skykomish (cfs)	SF Skykomish at Skykomish (cfs)	SF Skykomish near Index (cfs)
50	2-year	7,200	13,500	23,300
10	10-year	14,600	26,700	44,300
4	25-year	18,900	34,500	56,100
2	50-year	22,400	40,800	65,400
1	100-year	26,100	47,400	75,000
0.2	500-year	35,600	64,500	99,200

TABLE 2.2-2
RECENT HIGH FLOWS AT THE SOUTH FORK SKYKOMISH RIVER AT SKYKOMISH GAGE (U.S. GEOLOGICAL SURVEY [USGS] 12131500), INSTALLED IN 2016

Date	Flows
2022-11-12	16,200 cfs
2020-02-01	20,400 cfs
2017-11-23	19,100 cfs

Ecological Context and Salmonid Use

The South Fork Skykomish River watershed is in good ecological condition relative to other King County drainages. Most of the area—predominantly in federal ownership—is managed for natural resources or is relatively unmanaged as wilderness (King County 2006). However, forestry-related uses throughout this drainage basin have affected downstream channel conditions. These impacts include altered basin hydrology, increased erosion and sediment inputs to the river caused by timber removal and forest roads, and reduced levels of large wood.

Residential development in these areas, while rural in nature, often encroaches on riverbanks and floodplains. In many places, riverside development has reduced the quantity and quality of riparian forests and resulted in bank hardening. These impacts alter natural rates of erosion, sediment delivery and storage, instream velocities, channel migration, and large wood recruitment (King County 2013).

Most of the South Fork Skykomish River was historically used only by resident fishes due to impassable falls in Snohomish County at approximately River Mile 1.9. The Washington Department of Fish and Wildlife (WDFW) began a trap-and-haul program in 1958 to move fish around Sunset Falls and Eagle Falls into the upper basin, which established local populations of Chinook and coho salmon, summer run steelhead, and bull trout (King County 2013).

Floodplain modifications, especially fill and armoring associated with roads and residential development, have adversely affected the river and its tributaries. Where roads are near stream channels and bridges cross channels, the stream banks are often armored with rock, limiting natural rates of erosion, channel migration, and large wood recruitment. For example, many reaches of the Beckler River are armored to protect Forest Service roads that access campgrounds, trailheads, and private roads that lead to private forestry operations. Likewise, fill and armor in the alluvial fan of the Miller River have adversely affected the river by reducing the amount of aquatic habitat available for spawning, rearing, and other essential life stages for salmonids, and by preventing natural processes related to water, sediment, and large wood. Alluvial fans are explained in the *Glossary* that precedes Chapter 1.

Historically, large wood was removed from channels and floodplains in conjunction with timber harvesting to allow for transport of logs downstream, and to increase flow capacity. Large wood removal in the watershed has altered channel morphology and caused lower pool frequency and higher velocities, negatively impacting spawning and rearing habitat (Haring 2002).

Beneficial functions of flooding and connected floodplains include recruitment of large wood, creation and maintenance of side channel habitat, routing and storage of coarse sediment, and connection to floodplain habitat for multiple aquatic species.

The Snohomish Watershed Forum (WRIA 7), the Lead Entity for salmon restoration in the Skykomish River in King County, identified six habitat enhancement projects to improve salmon conditions in the Skykomish River basin in its 2015-2025 project list. Two of these six (Beckler River Confluence Large Wood Project and Alpine Baldy Road

Decommissioning) have now been completed as of 2023 (Zyla et al. 2022). In addition, King County has incorporated habitat elements into recently completed flood protection facility repair projects.

Primary Flood and Erosion Hazards and Risks

The steep and narrow South Fork Skykomish River Valley generates deep, fast-moving flood flows capable of severe flooding and bank erosion. Floodplain mapping for the South Fork Skykomish River was updated in 2021 to provide more up-to-date information about flood hazards on the South Fork Skykomish River and Maloney Creek based on updated hydrology, more accurate topography, and refined modeling methods. Draft maps have been submitted to FEMA for review and approval.

King County mapped channel migration and landslide hazard areas in 2017 and 2016, respectively, within the South Fork Skykomish River to identify the potential impacts on flooding and risk to people and infrastructure within the river corridor (King County 2016a, 2017). Channel migration hazards generally are greatest on the outsides of meander bends in the river and in locations where one side of the river valley is bedrock and the opposite bank is alluvial floodplain material. King County has implemented mitigation for channel migration hazards in the Timberlane Village and Baring neighborhoods through property acquisition, outreach, and hazard communication.

The landslides active within the river corridor include rockfall, debris flows with alluvial fans, and deep-seated, complex landslide features (King County 2016a, 2018). These landslide and alluvial fan hazards have the potential to impact flood and channel migration hazards on the mainstem South Fork Skykomish River and its tributaries by delivering large volumes of sediment and wood to the channel and potentially damming the river, redirecting floodwaters across the floodplain. Debris flow hazards can also deliver large volumes of sediment and wood to the channel; because of these factors, infrastructure and structures in the floodplain and on alluvial fans are subject to flooding and channel migration hazards, including reach-length avulsions.

Roads in this basin typically run along, near, or over the river or lower portions of its tributaries, as well as across associated floodplains and historical channel migration areas (King County 2013), which presents flood and channel migration risk to roadways.

The Miller River is a tributary that enters the South Fork Skykomish at approximately River Mile 14.0. The Miller River delivers sediment to an alluvial fan that is building as the Miller River emerges into the valley of the South Fork Skykomish River. This area is highly prone to channel migration. The Old Cascade Highway and the BNSF Railway cross this active alluvial fan area of the Miller River and disconnect all of the fan except for the main Miller River channel from the South Fork Skykomish River.

In January 2011, the Miller River avulsed (i.e., abandoned its channel for a new route) into a new channel to the west of its former alignment, resulting in the destruction of 150 feet of the Old Cascade Highway. Formerly a through road that paralleled U.S. Route 2, the Old

Cascade Highway was permanently closed because of this event. Because the river created a new flow path, the Miller River bridge no longer spans the river. U.S. Route 2 now provides the sole east-west travel route through the area, and access to the Miller River community and recreation areas via Money Creek Road now relies on a single bridge over the South Fork Skykomish River. In 2023, King County completed a project to improve traffic safety and flooding on the remaining portions of Old Cascade Highway.

In September 2022, the Bolt Creek wildfire on the north side of the South Fork Skykomish River threatened the community of Grotto. If the wildfire had progressed to reach the sole-access Old Cascade Highway bridge, Miller River community members could potentially have been stranded on the south side of the river for an undetermined period. Nine alluvial fans on the slope affected by the Bolt Creek fire were determined to have moderate to high debris flow hazards following the Bolt Creek fire (Mickelson and Allen 2022), a level of hazard that is higher than it was prior to the fire. King County actively monitors the area for debris flows during times of intense rainfall and runoff.

Overview of the Upper Snoqualmie River Basin

The three forks of the Snoqualmie River (North, Middle, and South) begin in the high peaks of the Cascades, follow steep watercourses through the mountains, and combine to form the mainstem Snoqualmie River north of the City of North Bend. The river flows through the City of Snoqualmie and over Snoqualmie Falls. The drainage area upstream of the falls is referred to as the upper Snoqualmie River basin, which is approximately 367 square miles.

The South Fork Snoqualmie River basin drains 85 square miles and flows into the Snoqualmie River mainstem at River Mile 41.8, just downstream of the Middle and North Fork confluence in the Three Forks Natural Area. Upstream of Interstate 90 (I-90), land use is a mix of rural residential and forest lands. As the river approaches North Bend, land use transitions to low-density commercial and residential development. As the river moves north past North Bend, the river is largely unconfined and flows through a mix of rural residential and public lands.

The Middle Fork Snoqualmie River and North Fork Snoqualmie River basins drain 104 and 170 square miles, respectively. The Middle Fork generally flows west and then north at the base of Mount Si to its confluence with the North Fork. The two forks combine within Three Forks Park to form the mainstem Snoqualmie River and the South Fork joins just downstream.

Predominant land uses in the area are managed forests, parks and other public lands, and rural residential. The Snoqualmie Tribe reservation and other tribal trust lands are in this basin. Several small tributaries drain directly into the mainstem of the Snoqualmie River above Snoqualmie Falls, with Kimball Creek being the largest.

Confluence of Middle and North Fork Snoqualmie River, December 2023

Geology and Geomorphology

Each of the three forks of the Snoqualmie River above Snoqualmie Falls and within the flood hazard corridor is in a post-glacial valley that has incised into glacial sediments deposited during continental glaciation. The confluence of the three forks forms a complex alluvial fan that combines sediment deposition from the glacial runoff, the three fork rivers, and tributary streams, including Boxley, Clough, Ribary, and Kimball creeks. Much of the gravel and cobble sediment load in the upper Snoqualmie River is deposited upstream of Snoqualmie Falls where gradient and sediment-transport capacity decreases (Booth et al. 1991).

The headwaters of the South Fork Snoqualmie River are steep bedrock-dominated slopes and terrain derived from alpine glaciations. Above Twin Falls, at River Mile 10.0, material from glacial sediments and modern alluvium and colluvium make up the channel substrate (Bethel 2004). Below Twin Falls, the river channel and morphology transition to a shallower gradient, and the channel form becomes braided with multiple small channels and frequently shifting gravel bars. Near North Bend, the South Fork Snoqualmie River emerges onto a broad alluvial fan where sediment from both the South and Middle forks is deposited (Reid and Dunne 1996).

Intermittent revetments from River Mile 9.5 to River Mile 5.0 and the continuous levee system from River Mile 5.2 to River Mile 2.1 limit the potential for channel migration of the South Fork. The riverbed material is dominated by boulders, cobble, and gravel upstream of the levees. The riverbed in the leveed reach is dominated by gravel and cobble with significant local gravel bar accumulations. Downstream of River Mile 2.0, the lack of bank armoring allows the channel to widen, meander, and freely migrate. The bed material in this reach is dominated by gravel, sand, and silt. The deposition of bedload downstream of River Mile 2.0 combined with new sediment inputs from local bank erosion and wood loading contribute to rapidly changing channel locations.

Along most of their length, the North Fork Snoqualmie and Middle Fork Snoqualmie rivers flow primarily through unconsolidated deposits of boulders, cobble, gravel, sand, and silt that have been laid down and reworked by the rivers as they cut through glacially derived sediments. In places, the rivers abut older geologic materials at the edge of the valley floor, including older glacial deposits and the bedrock escarpment of Mount Si. Glaciers shaped the upper basin, including steering the North Fork southward to its confluence with the Middle Fork. The forks emerge from steep boulder and bedrock-dominated slopes and channels in the mountains and deposit their coarse sediment load on a broad, gently sloping valley floor (Booth et al. 1991). Intermittent levees and revetments along the two forks limit channel migration in places.

Hydrology and Hydraulics

The three forks of the Snoqualmie River (North, Middle, and South) begin in the high peaks of the Cascades, follow steep watercourses through the mountains, and combine to form the mainstem Snoqualmie River north of the City of North Bend. The river then flows through the City of Snoqualmie and over Snoqualmie Falls. Flows along the three forks are unregulated, with no major reservoirs in the system. Several hydroelectric facilities divert flows, including a dam operated by Puget Sound Energy immediately above Snoqualmie Falls. None of these hydroelectric facilities contain sufficient storage volume to influence downstream flooding. **Table 2.2-3** lists the flow quantiles developed from various gages on the Snoqualmie River system for FEMA floodplain mapping of the North, Middle, and South Forks of the Snoqualmie River. The period of record for the gages was from 1909 to 1997. More recent data with a longer period of record may result in different values.

TABLE 2.2-3
FLOW QUANTILES FOR THE NORTH FORK, MIDDLE FORK, AND SOUTH FORK OF THE SNOQUALMIE RIVER (IN CUBIC FEET PER SECOND)

Percent Annual Chance Exceedance	Return Period	North Fork at Mouth (cfs)	Middle Fork at Mouth (cfs)	South Fork at Mouth (cfs)
10	10-year	18,600	26,900	10,100
2	50-year	24,600	34,800	16,500
1	100-year	27,200	38,600	20,200
0.2	500-year	32,800	46,900	28,600

Ecological Context and Salmonid Use

All three forks of the upper Snoqualmie River drain a combination of wilderness and public and private timberlands in their uppermost reaches, much of which has been extensively logged. The upper reaches of the Middle and North Forks have relatively stable channels that flow through forested floodplains and support natural ecosystem functions. Once the forks leave the timberlands, residential development in the floodplain and channel migration zone increases, and segments of the once-dynamic channels are now armored and locked in place by levees and revetments that contribute to degraded ecological conditions. Natural river processes are more evident in the three forks area.

The natural barrier of Snoqualmie Falls prevents any migration of anadromous salmonids into the upper Snoqualmie River. Levees and revetments exist along all three forks. The physical characteristics of both the North and Middle forks are still affected by the legacy of logging activities. The lower segments of each fork are the most affected by development.

Riparian conditions vary greatly above Snoqualmie Falls. Headwater riparian areas are densely vegetated, mostly with conifers. On the valley floor, riparian vegetation becomes dominated by deciduous trees, and a range of rural to urban development has encroached on the river channels, often in old swales once occupied by one of the forks or the mainstem river (King County 2006).

Salmonid use above Snoqualmie Falls is limited to cutthroat and rainbow trout, mountain whitefish, and non-native brook trout. Although appropriate habitat is present and there are anecdotal reports of bull trout, a concerted survey effort to detect them following American Fisheries Society protocols in 2000 did not find any bull trout (King County 2006). The Middle Fork Snoqualmie River contains the most robust trout population and greatest abundance of large trout in the upper portion of the Snoqualmie River system (King County 2013).

Some beneficial functions of flooding and connected floodplains include the creation and maintenance of and access to floodplain off-channel habitat for multiple aquatic species, food web support, recruitment of large woody debris (LWD), routing and storage of coarse sediment, and access to off-channel habitats.

King County, in partnership with others, has completed numerous projects in the upper Snoqualmie basin that improve habitat conditions. The Snoqualmie Tribe recently completed an Upper Snoqualmie Resilient River Corridor Management Plan to improve fish and wildlife conditions and increase connectivity with the river in the upper Snoqualmie (above the falls). This Flood Plan identified 22 projects that the tribe and its partners will work to complete.

Since anadromous fish cannot reach the upper Snoqualmie River, the WRIA 7 group does not prioritize projects in the upper basin (although three are listed in their 10-year 2015–2025 plan, including one to remove knotweed from the upper basin).

Primary Flood and Erosion Hazards and Risks

In the upper Snoqualmie River Valley, flooding is typically overbank inundation by deep, slow-moving floodwaters, with some areas of deep and fast flows. Phase 4 floods, corresponding to severe flooding, have a return period of approximately 4.5 years (22 percent annual probability) (King County 2016b). Flooding and channel migration pose a risk to commercial and residential areas in the cities of Snoqualmie and North Bend and to residential areas in unincorporated King County. Significant areas within North Bend and Snoqualmie are in the mapped FEMA floodplain, and the City of Snoqualmie has the highest number of flood insurance claims in Washington state.

The lower reaches of the Middle and North Forks are subject to flooding and channel migration where rural residential development and agricultural land use are present. The discontinuous revetments and levees in this area provide some flood and erosion protection, but not flood containment. Levees in these reaches require frequent maintenance and repairs.

Upstream of I-90 are discontinuous levees and revetments along both banks of the South Fork Snoqualmie River. As the South Fork approaches North Bend, a series of continuous levees begins along both banks through the city, which protect low-density commercial and residential development. The levees were designed asymmetrically, with higher levees on the right bank, where the North Bend city center is located. The levees on both banks were designed to contain floodwater flow of 13,000 cubic feet per second (cfs), a flow which has an approximately 3 percent annual chance of being exceeded.

The geometry of the alluvial fan at the confluence of the three forks results in overbank floodwaters from the Middle Fork flowing toward the South Fork (King County 2014). An analysis of the network of channels on the alluvial fan indicates significant potential for enlargement. Enlargement of these channels would increase risks of erosion, channel migration, and avulsion (Perkins 1996). The potential for rapid relocation of channels and associated hazards on alluvial fans is difficult to quantify.

Sediment accumulating in reaches of all three forks locally affects flooding and channel migration hazards by periodically reducing channel capacity and influencing changing channel positions and erosion patterns. Channel migration, including lateral bank erosion and channel avulsion, occurs in these reaches. Potential avulsion channels between the Middle Fork and South Fork are frequently activated by groundwater and sometimes by surface water from the Middle Fork, highlighting mapped channel migration hazards. On the North Fork, dramatic changes in channel position near its confluence with the Middle Fork increased risk to the 428th Avenue SE bridge abutments and levee setback capital projects constructed on both sides of the channel.

King County mapped landslide hazards active within the river corridor that could impact flooding and channel migration hazards (2016). These include rockfall, debris flows with alluvial fans, and deep-seated, complex landslide features. Fan, debris flow, and rockfall hazards extend along South Fork Snoqualmie River and the I-90 corridor to the river's headwaters at Snoqualmie Pass. Rockfall debris from Mount Si is present in and controls the channel of the North Fork Snoqualmie River. In addition to flood and channel migration hazards from the three forks and mainstem Snoqualmie River, Kimball Creek presents flood risks to the City of Snoqualmie and Ribary Creek presents flood risks in the City of North Bend.

Overview of the Lower Snoqualmie River Basin

The lower Snoqualmie River basin begins at Snoqualmie Falls at River Mile 38.5, with the river generally flowing north toward Snohomish County. The lower Snoqualmie River meanders through a broad valley floodplain, flowing past the unincorporated community of Fall City and the cities of Carnation and Duvall. The river crosses into Snohomish County and continues for approximately 5.5 miles before it joins the Skykomish River near Monroe, forming the Snohomish River, which flows into Puget Sound in Everett.

Several tributaries join the lower Snoqualmie River, including the Tolt and Raging rivers, and Tokul, Patterson, Griffin, Harris, Tuck, and Cherry creeks. Most of these tributaries have relatively steep gradients until they meet the flat valley floor of the Snoqualmie River. The Tolt and Raging rivers are the largest tributaries, and both input large amounts of sediment into the Snoqualmie River, which provides important salmon spawning habitat at and downstream of their confluences.

Aside from the residential and commercial centers of Fall City, Carnation, and Duvall, most of the land use in the lower Snoqualmie River Valley is currently agricultural and low-density residential. Approximately 87 percent of the lower Snoqualmie River floodplain currently falls within the Snoqualmie Agricultural Production District, lands which were historically critical habitat for fish and wildlife and hunting and gathering areas for the Snoqualmie Tribe.

Future development in unincorporated King County in the lower Snoqualmie Valley is restricted by the FEMA floodway and zoning laws. Development is increasing in unincorporated Fall City, where most of the residential and commercial buildings are outside the regulatory floodplain. A proposed business district septic system will allow some limited additional commercial growth in this area. The system is not designed to accommodate full build-out of all lots in the commercial district, and at present it will allow for approximately 15 percent growth.

The City of Carnation is similar in population and development to Fall City, but future development is limited primarily by available undeveloped property. Many of the remaining developable properties are in the process of building medium to large residential developments. The City of Duvall is almost entirely outside of the floodplain, with most of the developed area located on the hillside above the river.

Geology and Geomorphology

Snoqualmie Falls forms the upstream boundary of the lower Snoqualmie River watershed, where the Snoqualmie River flows over a 286-foot escarpment of resistant volcanic bedrock. Downstream from the falls, the Snoqualmie River transitions from a confined bedrock channel to an alluvial channel and wide floodplain. The broad, low-gradient valley currently occupied by the lower Snoqualmie River was formed by glacial runoff (Booth 1994). As river sediments were deposited adjacent to the channel within the valley, the elevation of riverbanks increased several feet higher than the surrounding floodplain, resulting in the formation of alluvial ridges (Collins et al. 2003b; Collins and Montgomery 2011). With riverbanks at a higher elevation than much of the valley floor, even relatively small overbank flows can result in valley-wide flooding.

Lower Snoqualmie River flooding, December 2015

Much of the sediment load in the lower Snoqualmie River is contributed from high-gradient tributaries, including the Tolt and Raging rivers (Booth et al. 1991) and smaller creeks. The Tolt and Raging rivers deposit alluvial fans where they enter the valley of the lower Snoqualmie River near Carnation and Fall City, respectively, and these fans influence the mainstem Snoqualmie River channel course. Alluvial fans also formed where smaller tributary streams enter the relatively flat lower Snoqualmie River Valley. Tokul, Griffin, Harris, Adair, and Cherry creeks and other smaller tributaries all have alluvial fans present at their outlets to the Snoqualmie Valley bottom and historically contributed sediment to the river system.

Many tributaries to the Snoqualmie River have been heavily modified into straightened channels as they traverse the floodplain to the mainstem river, and these channels can also accumulate sediment. Much of the coarse sediment delivered from the larger tributaries is stored in the mainstem channel within a few miles downstream of their confluences, and some sediment remains in the fans on the floodplain. These sediment inputs affect the channel gradient of the lower Snoqualmie River both upstream and downstream of the confluences. Upstream of the confluences, the Snoqualmie River channel gradient is lower, and course sediment transport is limited. At the confluence and downstream from these alluvial fans, channel gradient and substrate size first increase and then progressively decrease, and the lower Snoqualmie River transitions from a cobble- and gravel-bedded river with multiple gravel bars and secondary channels to a sand- and silt-bedded, single-threaded meandering river.

Channel migration of the lower Snoqualmie River is limited by levees and revetments constructed at the beginning of the 20th century. The most dynamic segments of the lower Snoqualmie River are downstream of the alluvial fans of the Raging and Tolt rivers due to increased coarse sediment delivery, resulting in lateral migration and shifting by avulsion. In other meandering reaches of the river, lateral migration proceeds more slowly and avulsions, although infrequent, are a primary mode of channel change, which contributes to the formation of the oxbow lakes present throughout the lower Snoqualmie River Valley (Collins and Sheikh 2002; Collins et al. 2003b).

Hydrology and Hydraulics

Peak-flow hydrology of the lower Snoqualmie River is largely unregulated by dams and driven by runoff from fall and winter storms and snowmelt during the spring. Three run-of-the-river dams divert water for hydroelectric projects within the Snoqualmie River watershed at Snoqualmie, Twin, and Weeks falls, but do not have any flood storage capacity. Only the South Fork Tolt Dam, which impounds the South Fork Tolt Reservoir for the City of Seattle's municipal water supply and hydroelectric power generation, maintains storage capacity within the lower Snoqualmie River watershed. Seattle uses this storage capacity to provide limited regulation of the magnitude and duration of floods during the fall and winter flood season for the Tolt and lower Snoqualmie rivers. **Table 2.2-4** lists the flow quantiles developed for FEMA floodplain mapping of the lower Snoqualmie River. The quantiles are based on gage data with a period of record from 1930 to 2003. More recent data with a longer period of record may result in different values. **Table 2.2-5, Table 2.2-6, Table 2.2-7,** and **Table 2.2-8** show recent high-flow events and the highest flows recorded for the Snoqualmie River at two gage locations (Carnation and Snoqualmie) to illustrate the extent of recent and possible flooding in the subbasin.

TABLE 2.2-4
FLOW QUANTILES FOR THE LOWER SNOQUALMIE RIVER

Percent Chance Exceedance	Return Period	At Duvall (cfs)	At Carnation (cfs)	Near Snoqualmie (cfs)
10	10-year	53,400	58,200	51,700
2	50-year	75,800	82,400	71,000
1	100-year	84,600	91,800	79,100
0.2	500-year	99,700	113,300	95,200

TABLE 2.2-5
RECENT HIGH FLOWS, SNOQUALMIE RIVER NEAR SNOQUALMIE GAGE (USGS 12144500)

Date	Flows
2022-11-05	36,700 cfs
2022-03-01	36,400 cfs
2019-10-22	46,900 cfs
2015-12-09	49,500 cfs
2015-11-17	48,000 cfs
2015-01-05	50,100 cfs

TABLE 2.2-6
HIGHEST FLOWS RECORDED AT THE SNOQUALMIE GAGE SINCE PEAK MEASUREMENTS BEGAN IN 1958

Date	Flows
1990-11-24	74,300 cfs
1959-11-23	61,000 cfs
2009-01-07	60,700 cfs

TABLE 2.2-7
RECENT HIGH FLOWS, SNOQUALMIE RIVER NEAR CARNATION GAGE (USGS 12149000)

Date	Flows
2022-03-01	46,900 cfs
2020-02-07	49,200 cfs
2015-12-09	56,200 cfs
2015-11-18	46,600 cfs
2015-01-06	53,900 cfs

TABLE 2.2-8
HIGHEST FLOWS RECORDED SINCE CARNATION GAGE WAS INSTALLED IN 1929, DURING SPECIFIC FLOOD EVENTS

Date	Flows
2009-01-08	82,900 cfs
2006-11-7	71,800 cfs
1990-11-24	65,200 cfs

Ecological Context and Salmonid Use

The lower Snoqualmie River has a wide valley floor that is approximately 1 mile wide, except for just south of the King-Snohomish boundary, where it is more than 2 miles wide. The valley floor contains numerous large, old oxbow ponds, side channels, and shallow swales, marking where the river once flowed. Tributaries meander along the valley floor for a significant distance before emptying into the mainstem river (King County 2006).

The lower Snoqualmie River supports the freshwater life-stages of various salmonids, including wild populations of Chinook, chum, coho, and pink salmon; mountain whitefish; and rainbow-steelhead, cutthroat, and non-native brook trout. A riverine form of sockeye salmon has also been found in the lower Snoqualmie River (King County 2006, 2018). Anadromous fish use the entire length of the Snoqualmie River below Snoqualmie Falls, as well as many of the river's tributaries.

The presence of many abandoned oxbows indicates that, historically, the Snoqualmie River migrated across its floodplain, creating and maintaining diverse aquatic habitats. Construction of levees and revetments along the mainstem river, combined with land clearing to support extensive agricultural development, reduced natural floodplain function and the quantity and quality of instream salmon habitat. Additionally, access to many off-channel habitats and tributaries has been eliminated or impaired by the combination of culverts, bank armoring, and mainstem channel incision (Haring 2002).

Observations from 2017 indicated that stream banks were armored across more than 40 percent of the lower Snoqualmie River, large wood abundance was found to be low, and most wood was relatively small. Since the adoption of the 2005 Snohomish River Basin Salmon Conservation Plan (2005 Salmon Plan), stream bank vegetation has increased, and the percentage of tree coverage has grown across the riparian corridor, but riparian conditions are still quite degraded as compared to historic conditions (King County 2018). Likewise, while large wood abundance (pieces/mile) has increased, it remains significantly less than historic conditions. Large wood placement and side channel creation and restoration are considered integral short-term measures to support habitat-forming processes until restored riparian forests can support large wood recruitment (King County 2018).

The Snohomish Salmon Recovery Forum and Snoqualmie Watershed Forum have identified and are guiding implementation of numerous salmon enhancement projects in the lower Snoqualmie River basin to address primary limiting factors. A total of 19 habitat restoration projects are identified in their 10-year plan (2015-2025) directly along or within the lower Snoqualmie River, and the long process of habitat restoration remains ongoing.

Primary Flood and Erosion Hazards and Risks

The lower Snoqualmie River Valley is prone to extensive and somewhat regular flooding, with multiple flood events that inundate farmland and low-lying roads in most years. With riverbanks at a higher elevation than much of the valley floor, even relatively small overbank flows can result in valley-wide flooding. Property owners and residents can sometimes be isolated for days by floodwater. Due to the widespread nature of flooding and the frequency that roads are inundated, driving into flood areas is one of the greatest risks to public safety.

Four major roads cross the floodplain of the Snoqualmie River and are subject to flooding: NE Tolt Hill Road, NE Carnation Farm Road, NE 124th Street, and NE Woodinville Duvall Road. NE Tolt Hill Road and NE 124th Street are the first two of these roads to close and may close during even relatively minor flooding. Flooding of NE Carnation Farm Road and NE Woodinville Duvall Road does not typically occur until flooding is significant. When these routes are closed, it can limit access to and from communities on the east side of the Snoqualmie Valley and isolate these communities from services and places of employment.

Lower Snoqualmie River flooding in Duvall, December 2015

Many areas of the Snoqualmie River floodplain typically experience low-velocity floodwaters; however, local conditions, such as changes in floodplain or channel gradient or the overtopping of levees or roads, can contribute to higher velocities that pose hazards to public and private infrastructure. Larger flood events can cause high-velocity flows in areas of development, potentially posing risks to structures and public safety if individuals are isolated by floodwaters.

Many revetments, both public and private, and a few levees are present along the lower Snoqualmie River. The function of this infrastructure is primarily to limit local bank erosion and channel migration. While a few flood protection facilities reduce the limits of inundation during smaller floods, they do not provide containment at higher flows. Many revetments adjacent to the lower Snoqualmie River were constructed to protect roads, highways, or other public infrastructure adjacent to the channel, maintain the channel alignment through bridges, or protect agricultural areas.

Flood hazards in alluvial fan areas where steep tributaries discharge onto the flat Snoqualmie River floodplain, particularly at the mouths of the Tolt River near Carnation and the Raging River near Fall City, are influenced by high rates of sediment deposition, which cause increased rates of erosion and channel migration. Flooding patterns at these large tributary confluences are complicated and highly influenced by the timing and relative magnitude of tributary and mainstem flooding.

Overview of Tolt River Basin

The Tolt River is the largest tributary of the Snoqualmie River below Snoqualmie Falls. It enters the Snoqualmie River from the east, near the City of Carnation. The Tolt River drains a total area of about 100 square miles, with headwaters at the crest of the Cascades and an elevation change of over 4,000 feet from crest to the Snoqualmie River. The North Fork Tolt and South Fork Tolt rivers join near River Mile 8.4.

The upper Tolt River basin is mostly within a forest production district, where ongoing timber harvesting has occurred since the early 1900s. The City of Seattle owns the timberland surrounding the South Fork Tolt Reservoir and Dam, which is managed primarily to protect water quality and quantity for municipal water supply. Land use in the Tolt River Valley downstream of River Mile 6.0 is primarily residential development that ranges from low density in the upstream end to higher density near the downstream end in Carnation.

Geology and Geomorphology

The steep, high-relief headwaters of the Tolt River basin are primarily underlain by volcanic and intrusive bedrock of the Cascade Range. Advances of alpine glaciers carved the main upper valleys of the North and South Forks of Tolt River (Bethel 2004), including the part inundated by the South Fork Tolt Reservoir. The South Fork Tolt Dam at the outlet of the South Fork Tolt Reservoir was constructed along a moraine (a mass of rocks and sediment carried down and deposited by a glacier). Both forks of the Tolt River incised deep, confined valleys and narrow gorges into unconsolidated glacial sediments and underlying volcanic bedrock (Dragovich et al. 2010).

The mainstem Tolt River flows 8.4 miles from the confluence of the North and South Forks of the Tolt River to its confluence with the Snoqualmie River south of Carnation. From River Mile 8.4 to River Mile 6.0, the Tolt River is confined within a deeply incised valley that has cut a trough through glacial sediments (Dragovich et al. 2010). The Tolt River emerges from its steeper and confined reaches at River Mile 6.0 to flow through a relatively narrow valley floor that widens downstream to the confluence with the Snoqualmie River. Along this reach, steep valley walls consist mostly of glacial and non-glacial deposits, with extensive large, deep-seated landslide deposits along both valley walls. Similar landslides are present in the portion of the river above the Snoqualmie River floodplain. A tall, shallow landslide is also active on the left valley wall of the Snoqualmie River directly opposite the Tolt-Snoqualmie confluence. These landslides serve as a major source of both suspended and bedload sediment where the river migrates and erodes the toe of the slides.

The lower Tolt River Valley opens to the broader Snoqualmie River Valley near River Mile 2.0. The City of Carnation is on the alluvial fan built by the Tolt River across the Snoqualmie River floodplain. At the eastern edge of the Snoqualmie River Valley, the surface of the fan stands 30 to 40 feet above the underlying valley floor. The elevated topography of the alluvial fan has effectively confined the Snoqualmie River to the western edge of the Snoqualmie Valley.

From approximately River Mile 5.0 to the confluence with the Snoqualmie River, the Tolt River is highly susceptible to high rates of lateral erosion, meander migration, and channel avulsions. These processes are now limited by the levee system in the Carnation reach. Historical references, such as General Land Office maps from 1873 and 1936 aerial photography, indicate that, prior to European settlement, this reach of the river was a highly mobile, more sinuous, multiple-threaded channel and major adjustments, such as down-valley meander migration and channel avulsions, were common.

Hydrology and Hydraulics

The Tolt River is characterized by a mixed rainfall-snowmelt hydrologic regime with elevated runoff during the fall and winter flood season and the spring freshet. About 20 percent of the overall Tolt River basin is regulated by the South Fork Tolt Dam, located 8 miles upstream of the confluence of the North and South Forks of the Tolt River. The South Fork Tolt Dam impounds a 56,000-acre-foot reservoir, which Seattle Public Utilities (SPU) has managed since 1964 to supply about 30 percent of the drinking water for 1.5 million people in and around Seattle. In 1996, a 16.8-megawatt hydroelectric facility was completed along the South Fork Tolt River and is operated by Seattle City Light.

The South Fork Tolt Dam, completed in 1963, operated by SPU and located 16 miles upstream of Carnation on the South Fork Tolt River, is the only dam within the Tolt and Snoqualmie river basins with storage capacity during the flood season. The South Fork Tolt Dam is not operated primarily for flood control; however, during winter flood season, the reservoir is operated to maintain a flood storage volume to minimize risks to the dam. Hydrologic analyses have demonstrated that the effect of reservoir management is that flood magnitudes for a 1 percent annual chance flow and a 50 percent annual chance flow are reduced approximately 20 percent and 30 percent, respectively (Watershed Science and Engineering 2015). If the reservoir is full prior to a storm event, however, it does not provide any flood reduction benefit.

Table 2.2-9 lists the flow quantiles developed for FEMA floodplain mapping of the Tolt River for a period of record from 1938 to 1993. More recent data or a longer period of record may result in different values. **Table 2.2-10** and **Table 2.2-11** illustrate recent high flows and the highest flows recorded on the Tolt River.

TABLE 2.2-9
FLOW QUANTILES FOR THE TOLT RIVER

Percent Chance Exceedance	Return Period	At Mouth (cfs)	USGS Gage 12148500 near Carnation (cfs)
10	10-year	13,900	11,900
2	50-year	19,500	16,700
1	100-year	22,000	18,800
0.2	500-year	27,800	23,800

TABLE 2.2-10
RECENT HIGH FLOWS, TOLT RIVER NEAR CARNATION GAGE (USGS 12148500)

Date	Flows
2020-02-01	9,740 cfs
2015-01-05	9,340 cfs
2009-01-08	13,800 cfs

TABLE 2.2-11
HIGHEST PEAK FLOWS RECORDED AT TOLT RIVER NEAR CARNATION GAGE (USGS 12148500) SINCE MEASUREMENTS BEGAN AT THE GAGE IN 1929

Date	Flows
1959-12-15 (before South Fork Dam was built)	17,400 cfs
1951-02-09 (before South Fork Dam was built)	16,800 cfs

Ecological Context and Salmonid Use

The Tolt River is the largest tributary to the lower Snoqualmie River and is by far its greatest source of coarse sediment, including salmonid spawning gravel. This sediment forms a delta that is among the most heavily used reaches for salmonid spawning in the Snohomish River basin. The Tolt River delta exerts a great influence on the larger Snoqualmie River channel, constricting and steepening it enough to create a diversity of habitats, including large pools and gravel-bedded spawning riffles that differ greatly from the majority of the Snoqualmie River's low-gradient, sand- and silt-bedded, meandering channel (King County 2006). Observations from 2017 indicated that the banks were armored along more than 30 percent of the lower section of the Tolt River (King County 2018). Reaches in the Tolt River without levees have many more side channels than leveed reaches and much greater complexity (Haring 2002).

The Tolt River is used by all the same salmonids that use the lower Snoqualmie River, including Chinook, chum, coho, and pink salmon; mountain whitefish; and rainbow-steelhead and cutthroat trout (King County 2006). Bull trout and Dolly Varden may also utilize this area, but sightings are extremely rare (Haring 2002). The lower Tolt River supports high-quality habitat for both juvenile and adult salmonids and is important for the persistence of both ESA-listed and non-listed salmonid populations in the Snoqualmie River watershed (King County 2018).

The lower Tolt River suffers from reduced large wood recruitment and accumulation, alteration and loss of riparian habitats, floodplain modification, and disconnection of off-channel and side channel habitats via levees and bank hardening (Haring 2002). Research has found that off-channel habitats away from the mainstem of the river are crucial for providing juvenile salmon with shallow, slow-water habitat, especially during floods (King County 2018). Salmon recovery efforts in the watershed have identified seven high-priority salmon enhancement projects in the 2015-2025 10-year plan along the Tolt River.

Primary Flood and Erosion Hazards and Risks

The Tolt River basin is relatively steep, generating fast and erosive flows. Landslide hazards are common in the portion of the river above the Snoqualmie River floodplain, upstream of Carnation. Phase 4 floods, corresponding to severe flooding, have a return period of approximately 2.8 years (or 35 percent probability) on the Tolt River (King County 2016b).

King County mapped channel migration and landslide hazard areas in 2017 and 2016, respectively, within the Tolt River to identify the potential impacts on flooding and risk to people and infrastructure within the river corridor (King County 2016a, 2017b). The 2017 channel migration mapping updated 1996 mapping by King County for the Tolt River. The landslide hazard mapping identifies several locations where the active river channel is in contact with the toe of a large, deep-seated landslide. These areas are especially hazardous because of the potential for channel migration to destabilize the landslide and the potential for the landslide to partially or completely block the river channel.

Upstream of the City of Carnation, Tolt River Road NE on the north side of the river is a sole access road ending at River Mile 6.0 in the Rio Vista neighborhood. In this steep reach, the river flows between steep, landslide-prone valley walls, and the floodplain gradually widens downstream. The Tolt River in this reach is highly susceptible to high rates of bank erosion, lateral channel migration, and channel avulsions. Land use in this reach includes low-density residential development.

In 2019, King County completed a project to reduce flood risks and improve fish and wildlife habitat in the former San Souci neighborhood, near River Mile 4.0. This neighborhood was in a dynamic stretch of the Tolt River, with active flood, erosion, and landslide hazards. Property acquisitions from willing sellers began in the early 1990s to move people and residential structures out of harm's way. The project removed 16 at-risk homes from an area that frequently flooded and reconnected the Tolt River with 33 acres of floodplain.

Flood Patrol on the Tolt River, February 2021

From River Mile 2.0 to the Snoqualmie River, the Tolt River is within its historical alluvial fan and is referred to as the leveed reach. The river historically migrated across the extent of the alluvial fan but is now incised into a channel that is largely confined by the existing levee system on both banks. Land use includes residential, commercial, and agricultural properties in the City of Carnation and unincorporated King County. Flooding is primarily caused when floodwaters overtop or damage the Tolt levees or Snoqualmie River flooding backs into the lower reach of the Tolt River and adjacent lands. Surrounding lands can be affected by inundation and by fast, erosive flows. Work is underway to set back the Lower Frew Levee in this reach, with construction expected within the next five to 10 years. Other levees are identified for improvement or future setback projects by the Tolt River Capital Investment Strategy (King County 2017).

Although unlikely, the Tolt River Dam and Reservoir has the potential to fail, causing widespread flooding to the City of Carnation. The City of Seattle maintains an advanced dam failure warning system, including monitoring instruments at the site, cameras at strategic locations, and sirens along Tolt River Road and within the City of Carnation. The warning system is automated and monitored by operators in the SPU Operations Control Center 24 hours a day, 7 days a week (City of Seattle 2023).

Overview of the Raging River Basin

The Raging River flows into the Snoqualmie River at the unincorporated community of Fall City about 4 miles downstream of Snoqualmie Falls. The Raging River drains an area of about 33 square miles. There is an overall elevation change of about 3,500 feet from the headwaters southeast of Tiger Mountain to the mouth, with a mainstem channel length of about 15 miles. There are no major dams in this basin.

The entire basin is in unincorporated King County. The unincorporated communities of Preston, downstream of I-90 near River Mile 4.5, and Fall City, at the confluence of the Raging and Snoqualmie rivers, are centers of residential and commercial land use. Levees line both banks along the lower 1.5 miles of the river. Much of Fall City is built on the Raging River's alluvial fan. Upstream of Fall City, rural residential development exists along much of the Raging River. Timber harvest has been the main land use in the upper two-thirds of the

Raging River basin since the early 1900s. Most of the timberland in the basin headwaters area is publicly owned.

Geology and Geomorphology

The Raging River is a relatively short, steep, dynamic river. Prominent peaks within the steep headwaters of the Raging River, including Tiger, Taylor, and Rattlesnake mountains, are largely underlain by sedimentary and volcanic bedrock, whereas unconsolidated glacial sediments comprise most of the lower watershed. The steep, narrow channel incised into a watershed with a narrow valley, forested mountain headwaters, and steep valley slopes. Landslides and debris flows occur frequently in the unconsolidated glacial sediments that line the valley walls.

At about River Mile 8.3, the Raging River emerges from the steep and narrow upper valley to flow across a still-relatively narrow alluvial floodplain. From River Mile 8.3 to River Mile 4.9 at I-90, the mainstem channel flows generally northwest and becomes increasingly wider, less confined, more sinuous, and more depositional. This reach upstream of I-90 exhibits the highest degree of lateral migration, although it is restricted by bank armoring in some locations.

At I-90, the river turns abruptly to the northeast and flows through a confined inner gorge. The river from I-90 to River Mile 1.5 is steeper and narrower than the reach upstream of I-90. Here the river's active floodplain is generally only a few hundred feet wide and bounded by alluvial terraces or the landslide-prone valley wall. The channel bed is largely boulder-dominated.

The Raging River exits the inner gorge near River Mile 1.5, where the broader Snoqualmie Valley opens, allowing the river flow to build a broad alluvial fan at its confluence with the Snoqualmie River. Much of Fall City is located on the alluvial fan built by the Raging River. The river channel is on the far right (east) side of this alluvial fan. This lower reach is confined by levees along both banks, effectively eliminating channel migration and any potential for the channel to move across the alluvial fan or interact with its floodplain to create and maintain side channels or other floodplain habitats.

The Raging River channel pattern has small-radius, open meander bends, and flows in a single-thread channel through most of its unleveed length, whether within the tightly confined gorge downstream of I-90 or within the relatively narrow floodplain upstream of I-90. Although relatively small, steep, and confined, the Raging River has a rapidly migrating channel (King County 2019; Shannon and Wilson 1991). Historical aerial photographs indicate that, prior to the establishment of the levee network on the alluvial fan, the Raging River in the Fall City reach was a highly mobile, more sinuous, multiple-threaded channel, likely also exhibiting rapid rates of adjustment such as lateral channel migration and channel avulsions.

Hydrology and Hydraulics

Flood hydrology of the Raging River is driven by rainfall during storms from November through February. Unlike the watersheds of the adjacent Cedar and Snoqualmie rivers that originate in the Cascade Range, the Raging River watershed drains relatively low-elevation foothills of the Cascade Range that do not develop an appreciable winter snowpack. Overall relief of the Raging River's small 33-square-mile watershed reaches only 3,500 feet. The resultant basin geometry contributes to flashy, short-duration floods that rise and recede quickly and high-velocity and erosive flows within its steep channel and confined floodplain.

King County and other agencies use the USGS gage 12145500 near Fall City for flood monitoring on the Raging River. This gage is located at River Mile 2.8 and records runoff from 93 percent of the basin. Peak-flow magnitudes and recurrence intervals were calculated for the FEMA Flood Insurance Study based on flows measured at this gage for the period of record from 1945 to 1992, plus an historic event in 1932. Because no gage exists at the Raging River mouth, peak-flow magnitudes at that location are estimated by the ratio of drainage areas at the mouth and at USGS gage 12145500. **Table 2.2-12** lists the flow quantiles developed for FEMA floodplain mapping of the Raging River. More recent data with a longer period of record may result in different values. **Table 2.2-13** and **Table 2.2-14** list recent high flows and the highest flows recorded for the Raging River.

TABLE 2.2-12
FLOW QUANTILES FOR THE RAGING RIVER

Percent Chance Exceedance	Return Period	At Mouth (cfs)	USGS Gage 12145500 (cfs)
10	10-year	4,031	3,790
2	50-year	6,286	5,910
1	100-year	7,413	6,970
0.2	500-year	10,465	9,840

TABLE 2.2-13
RECENT HIGH FLOWS, RAGING RIVER NEAR FALL CITY GAGE (USGS 12145500)

Date	Flows
2020-02-06	3,280 cfs
2015-12-09	3,520 cfs

TABLE 2.2-14
HIGHEST PEAK FLOWS RECORDED AT RAGING RIVER NEAR FALL CITY GAGE (USGS 12145500) SINCE GAGE WAS INSTALLED IN 1945

Date	Flows
1990-11-24	6,220 cfs
1986-11-23	5,330 cfs
1990-01-09	4,640 cfs

Ecological Context and Salmonid Use

The Raging River is the second largest and second most ecologically influential tributary to the lower Snoqualmie River. It is a major contributor of gravel to the lower Snoqualmie River, with its delta locally constricting and steepening the lower Snoqualmie River channel. This constriction creates a river reach much different from most of the lower Snoqualmie River and results in high-quality spawning and rearing conditions for salmonids in the mainstem lower Snoqualmie River. Its proximity to the upper extent of anadromous fish use at Snoqualmie Falls (located about 4 miles upstream) and its distance from the Tolt River (about 11 miles downstream) provides spatial separation of salmonid spawning habitats that may be helpful in maintaining geographic distribution and genetic diversity, two important factors in maintaining viable salmon populations.

Observations from 2017 indicated that stream banks were armored across more than 40 percent of the lower Raging River, impairing riverine and floodplain processes and degrading juvenile salmon-rearing habitat conditions. Within the riparian zone, primary land cover consisted of trees with secondary land cover consisting of impervious surfaces and shrubs (King County 2018).

The lower Raging River is used by Chinook, chum, and coho salmon, rainbow trout (including winter steelhead), cutthroat trout, mountain whitefish, and, rarely, bull trout. Historically, pink salmon were abundant, but since the 1950s they have mostly disappeared. It is also possible that a riverine form of sockeye salmon spawn in the lowermost reaches of the river, as they have been found elsewhere in the Snoqualmie River. The Raging River is in the highest tier of Chinook salmon use, meaning that it contains at least 12 percent of the total spawning escapement for the Snohomish River basin (Haring 2002, King County 2006).

The lower third of the 15 total miles of the Raging River exhibits highly constrained and degraded channel and floodplain conditions. Levees from the mouth to River Mile 1.4 cut off wetlands and prevent the channel from meandering and side channels from developing. Mature riparian forests are lacking, which limits the potential for large wood recruitment along the Raging River. This lack of large wood results in few pools and simplified salmon habitat (Haring 2002; King County 2006). Fish passage barriers exist on tributaries, and levees limit access to off-channel floodplain habitat (Haring 2002; King County 2018).

Primary Flood and Erosion Hazards and Risks

The Raging River basin is relatively steep and short, producing floods that peak and recede quickly and have fast and erosive flows along the steep channel and narrow floodplain. The river basin, from the end of Upper Preston Road SE near River Mile 8.3 downstream to I-90 at River Mile 4.9, has a moderate gradient and, because of relatively limited confinement by flood protection infrastructure, has high rates of lateral migration. Low-density residential development is impacted by flood inundation, bank erosion, and landslide and debris flows, and is also at risk from channel migration and avulsion. Preston-Fall City Road SE runs the length of the river valley from I-90 downstream to Fall City. Flood protection infrastructure, which requires monitoring and recurrent repairs, protects the bank where the road is adjacent to the channel between River Miles 3.0 and 4.0.

Upper Preston Road damage on the Raging River, November 2006

King County mapped channel migration and landslide hazard areas in 2019 and 2016, respectively, within the Raging River to identify the potential impacts on flooding and risk to people and infrastructure within the river corridor (King County 2016a, 2019). The 2019 channel migration mapping was an update of earlier mapping done by King County in 1991 (Shannon and Wilson 1991).

Although the rates of channel migration are lower than upstream of I-90, the active channel is eroding into the valley margin in several locations, posing risks to private and public infrastructure due to bank erosion. Local irregularities in geologic conditions appear to contribute to complex subsurface drainage pathways that also cause local settlement and hill-slope instability.

In its downstream reach, the Raging River historically migrated across the extent of its alluvial fan but is now largely confined throughout by continuous levees on both banks, which are intended to limit channel migration and damage caused by flooding. Flooding in this reach is caused when the levees are overtopped or damaged and by mainstem Snoqualmie River flooding, impacting residential and commercial properties.

Potential Impacts from Climate Change and Other Future Changes

South Fork Skykomish River

By the 2080s, the 10-year and 100-year peak flow events for the South Fork Skykomish River near Index (USGS ID: 12133000) are projected to increase 34 percent (range of 1 to 85 percent) and 40 percent (range of -11 to +123 percent), respectively, under a high greenhouse gas emissions scenario, relative to the 1970–1999 average (CIG Phase 2 report).[4] Changes in peak flows are influenced by both the declines in snowpack and by higher intensity heavy rain. Impacts from these changes may include increases in the size and frequency of risks posed by flooding and channel migration hazards. Larger and more frequent floods increase the risk of levee and revetment damage, bank erosion, inundation of floodplain areas, damage to public and private infrastructure, and isolation of communities that can be cut off by road flooding. Any increase in development in flood or channel migration hazards areas will increase flood risks.

The heavily forested condition of the South Fork Skykomish River watershed makes it susceptible to wildfires, which are increasing in frequency and severity in drier regions of the western U.S. due to the accumulation of fuels from wildfire suppression in the 20th century combined with the effects of climate change. In 2022, the Bolt Creek fire burned more than 14,000 acres in the basin, which started on the west bank of the Beckler River and spread to the slopes above the South Fork Skykomish River for about 3 miles in the vicinity of the communities of Grotto and Baring. Nine alluvial fans on the slope affected by the Bolt Creek fire were determined to have moderate to high debris flow hazards following the fire (Mickelson and Allen 2022) and are being actively monitored during the flood season.

[4] Results based on an ensemble average of 12 regional climate model scenarios (using the Weather Research and Forecasting [WRF] model) and a high greenhouse gas scenario (RCP 8.5) from the UW Climate Impacts Group (CIG) Phase 2 assessment, completed in June 2020 and updated in November 2020 (Mauger and Won 2020). Phase 3 of the CIG study, scheduled for completion in 2024, will update these projections and may result in higher projected changes than that shown here.

Upper Snoqualmie River

By the 2080s, average streamflow for October through March is projected to increase by 15 to 33 percent for the Snoqualmie River near Snoqualmie (USGS ID: 12144500), relative to the 1970–1999 average. Changes in peak flows are influenced by both the declines in snowpack and by higher intensity heavy rain (CIG Phase 1 Report, Lee et al. 2018). Impacts from these changes may include increases in the size and frequency of risks posed by flooding and channel migration hazards. Larger and more frequent floods increase the risk of levee breaching, levee and revetment damage, bank erosion, inundation of floodplain areas, damages to public and private infrastructure, and isolation of communities that can be cut off by road flooding. Any increase in development in flood or channel migration hazards areas will result in an increase in flood risks.

Lower Snoqualmie River

By the 2080s, the 10-year and 100-year peak flow events for the Snoqualmie River near Carnation (USGS ID: 12149000) are projected to increase 24 percent (range of -10 to 92 percent) and 40 percent (range of -18 percent to +103 percent), respectively, under a high greenhouse gas emissions scenario, relative to the 1970–1999 average (Mauger and Won 2020). Changes in peak flows are influenced by both the declines in snowpack and by higher intensity heavy rain (Lee et al. 2018). Impacts from these changes may include increases in the size and frequency of risks posed by flooding and channel migration hazards. Larger and more frequent floods increase the risk of levee and revetment damage, bank erosion, inundation of floodplain areas, damages to public and private infrastructure, impacts on agricultural production, and isolation of communities that can be cut off by road flooding. Any increase in development in flood or channel migration hazards areas will increase flood risks.

Tolt River

By the 2080s, the 10-year and 100-year peak flow events for the Tolt River near Carnation (USGS ID: 12148500) are projected to increase 11 percent (range of -12 to +69 percent) and 43 percent (range of -11 to +119 percent), respectively, under a high greenhouse gas emissions scenario, relative to the 1970–1999 average (Mauger and Won 2020). Changes in peak flows are influenced by both the declines in snowpack and by higher intensity heavy rain (Lee et al. 2018). Impacts from these changes may include increases in the size and frequency of risks posed by flooding and channel migration hazards. Larger and more frequent floods increase the risk of levee breaching, levee and revetment damage, bank erosion, inundation of floodplain areas, damages to public and private infrastructure, and isolation of communities that can be cut off by road flooding. Any increase in development in flood or channel migration hazards areas will result in an increase in flood risks.

Raging River

By the 2080s, the 10-year and 100-year peak flow events for the Raging River near Fall City (USGS ID: 12145500) are projected to increase 10 percent (range of -6 to +58 percent) and 24 percent (range of -22 to +96 percent), respectively, under a high greenhouse gas emissions scenario, relative to the 1970–1999 average (Mauger and Won 2020). Due to the relatively low elevation of the Raging River basin compared to other parts of the Snoqualmie River watershed, changes in peak flows are influenced primarily by projected increases in higher intensity rain events (Lee et al. 2018). Impacts from these changes may include increases in the size and frequency of risks posed by flooding and channel migration hazards. Larger and more frequent floods increase the risk of levee and revetment damage, bank erosion, inundation of floodplain areas, damage to public and private infrastructure, and isolation of communities that can be cut off by road flooding. Any increase in development in flood or channel migration hazards areas will result in an increase in flood risks.

Risk Assessment

A flood hazard risk assessment using Hazus evaluated the effects of riverine flooding on over 38,000 total structures in the South Fork Skykomish/Snoqualmie River watershed. This analysis revealed the following:

- In the entire watershed, 3,381 structures were found to be exposed to the 10 percent annual chance flood, 5,285 structures were found to be exposed to the 1 percent annual chance flood, and 5,692 structures were identified as exposed to the 0.2 percent annual chance flood.
- Of the 747 critical facilities located in the watershed, 143 are exposed to the 10 percent annual chance flood, 194 are exposed to the 1 percent annual chance flood, and 202 are exposed to the 0.2 percent annual chance flood.
- An estimated 127 of the 140 repetitive loss structures are exposed to the 10 percent annual chance flood, 132 are exposed to the 1 percent annual chance flood, and 133 are exposed to the 0.2 percent annual chance flood.

From the numbers of structures identified as exposed to flooding, Hazus generated estimates of potential flood damages. **Table 2.2-15** illustrates the resulting potential flood damages in the watershed for three different return intervals.

TABLE 2.2-15
SUMMARY RESULTS FROM HAZUS ANALYSIS OF POTENTIAL RIVERINE FLOOD DAMAGES IN THE SOUTH FORK SKYKOMISH/SNOQUALMIE RIVER WATERSHED

Percent Chance Exceedance	Return Period	Potential Structure and Contents Damage – All Structures	Potential Structure and Contents Damage – Critical Facilities
10	10-year	$30,866,442	$11,335,489
1	100-year	$185,786,961	$19,374,317
0.2	500-year	$625,463,491	$35,851,264

2.3 Lake Washington/Cedar/Sammamish River Watershed

Watershed at a Glance – Lake Washington/Cedar/Sammamish Watershed

WRIA	• WRIA 8
River systems/reaches included	• Cedar River • Sammamish River • Issaquah Creek
Basin size	• 692 square miles
Key tributaries	• Rex River; Taylor, Peterson, and Rock creeks; Bear, Little Bear, North, and Swamp creeks; Tibbetts, and Laughing Jacobs creeks; Holder, Carey, Fifteenmile, and McDonald creeks; the North and East Forks of Issaquah Creek
Dams/major infrastructure	• Ballard Locks • Chester Morse Lake • Masonry Dam • Landsburg Diversion Dam • Sammamish River Transition Zone
Key flood years	• 1906, 1911, 1951, 1990, 1996, 2006, 2009, 2020
Key issues in the basin	• Cedar River experiences fast, erosive flows • Fast, flashy flows along Issaquah Creek and other urban streams • Lakeshore flooding along Lake Sammamish • Urban flooding in City of Redmond
Salmonid species present	• Chinook, sockeye, steelhead and rainbow trout, coho, kokanee, bull trout, cutthroat trout, whitefish
Estimated economic damage from a 1 percent annual chance flood	• $4,733,843,730

The Lake Washington/Cedar/Sammamish watershed is the most populated watershed in Washington state, and it has a history of human modification to support its extensively developed character. Most significantly, the construction of the Ballard Locks and the Lake Washington Ship Canal between Lake Washington and Puget Sound resulted in significant changes throughout the watershed, lowering the elevation of Lake Washington by 9 feet, the abandonment of its outlet to the Duwamish River via the Black River, and rerouting of the Cedar River to flow into Lake Washington at Renton.

Unique among the other major river watersheds in King County, the major rivers (Cedar and Sammamish) of the watershed flow into a lake prior to entering the marine environment of Puget Sound. Human modifications in the early 20th century to the watershed's rivers and Lake Washington were designed to create a freshwater-to-saltwater connection that would support commerce and navigation.

- The **Cedar River** flows from protected headwaters in the Cascades through residential communities before entering the City of Renton and Lake Washington.

- The **Sammamish River** connects Lake Sammamish and Lake Washington. It is a slow-moving river with flood protection extending along its entire length. Bear, Little Bear, North, and Swamp creeks are primary tributaries that enter the river.
- **Issaquah Creek** is the most substantial tributary that flows into Lake Sammamish. It begins in unincorporated King County before flowing through the City of Issaquah and then the lake. It has experienced damaging flood events in recent years.
- Several tributaries empty into **Lake Sammamish** before it flows into the Sammamish River, and flooding of yards and docks along the lakeshore has been increasing in frequency since the mid-1990s.
- The water level in **Lake Washington** is strictly controlled by a locks system to protect a valuable freshwater port and does not see the same types of flooding impacts, but several tributaries to the lake present their own flooding challenges.

Input on Flooding in the Lake Washington/Cedar/Sammamish River Watershed

The Lake Washington/Cedar/Sammamish River watershed spans a wide variety of landscapes, including multiple rivers, large tributaries, and two large lakes, which resulted in a variety of reported flood impacts. Identified issues include sediment deposition impacting reaches of the Sammamish River, Cedar River, and Issaquah Creek, especially in downstream locations. Community members and partners described sediment deposition as reducing channel or conveyance capacity, impacting water quality, and increasing flood risks along numerous tributary streams, the Cedar River, and the Sammamish River. Stormwater runoff from upper watershed areas was often described as a primary issue affecting flooding in this watershed. In addition to riverine and tributary flooding impacts, community members highlighted flooding that affects waterfront properties along Lake Sammamish and indicated this flooding is exacerbated by upstream development, wave action during storm events, and insufficient lake outflow.

Overview of Cedar River Basin

The Cedar River drains 188 square miles of the central Cascade Range and flows 45 miles from its high-relief headwaters to its outlet to Lake Washington at Renton. The upper 78 square miles of the Cedar River drainage basin is located upstream of the outlet of Chester Morse Lake, a naturally occurring, moraine-dammed lake modified for municipal water supply and hydroelectric power generation by the City of Seattle. Two primary tributaries, the Cedar and Rex rivers, drain into Chester Morse Lake, and numerous small tributaries enter the Cedar River in its middle and lower reaches downstream of Chester Morse Lake.

The City of Seattle built three dams in the early 20th century on the Cedar River for the regulation of the Cedar River's discharge and municipal water supply. These include the Masonry Dam and the Crib Dam (reconstructed as the Overflow Dike), at the outlet of Chester Morse Lake, and the Landsburg Diversion Dam. The Cedar River watershed upstream of the Landsburg Diversion Dam, which includes about two-thirds of its overall watershed, is largely undeveloped forestland managed by the City of Seattle for the primary purpose of municipal water supply and a secondary purpose of hydroelectric power generation. Downstream of the Landsburg Diversion Dam, residential, commercial, and industrial development is present within the lower Cedar River corridor. Residential development shifts downstream from rural residential to suburban single-family near Renton. Commercial and industrial development also increases downstream in proximity to Renton.

The downstream-most 5 miles of the river and its floodplain are almost entirely within the City of Renton, which has the highest population density and largest business center within the Cedar River watershed, and its urban growth boundary. This area contains parks, single- and multi-family residential development, commercial development, and portions of the downtown business core. In addition to these developed areas, King County, local municipalities, and others manage hundreds of acres of open-space lands along the lower Cedar River between Landsburg Dam and the City of Renton.

Geology and Geomorphology

The Cedar River watershed is primarily underlain by bedrock of the Cascade Range and unconsolidated glacial sediments upstream and downstream of Chester Morse Lake, respectively. A glacial moraine impounded Chester Morse Lake, downstream of which the Cedar River eroded its present valley through glacial sediments. At the outlet of this valley near the City of Renton, the Cedar River deposited an alluvial fan at the southern margin of what became Lake Washington once it was impounded by this alluvial fan and separated from the Duwamish River Valley to the west (Dunne and Dietrich 1979).

Prior to European settlement in the mid-19th century, the Cedar River was a meandering, braided river with multiple secondary channels across its floodplain. The river flowed into the Black River, which flowed south from Lake Washington to the Duwamish River. Construction of the Hiram M. Chittenden (Ballard) Locks and Ship Canal by the U.S. Army Corps of Engineers (Corps) in 1916, which connected Lake Washington to Puget Sound, resulted in the water surface elevation of Lake Washington dropping by 9 feet. The Cedar River was then diverted from the Black and Duwamish rivers to flow into Lake Washington (Chrzastowski 1983).

During the 20th century, alterations to the Cedar River channel and hydrology included revetment construction, removal of large wood jams, and flow regulation, which largely constrained the Cedar River to a single-threaded, meandering channel. The Cedar River channel progressively narrowed, and channel migration rates decreased during the 20th century (Perkins 1994; Gendaszek et al. 2012).

The Cedar River transports sediment supplied to its channel from erosion of alluvial deposits and from landslides along its valley walls. During the 20th century, erosion of alluvial deposits was limited by the construction of revetments that reduced channel migration and peak-flood discharges. Upstream of the Cedar River alluvial fan at River Mile 1.7, excessive sediment deposition does not limit channel conveyance capacity. At River Mile 1.7, the Cedar River loses gradient. When the Cedar River was diverted to flow into Lake Washington, a straightened channel was constructed across the historical alluvial fan. However, the loss of gradient persists and backwater from the lake results in continued sediment deposition within the Cedar River at Renton.

The City of Renton, with assistance from King County Flood Control District (FCD) and the Corps, has repeatedly dredged the deposits from this lowest portion of the river. In 1998, the City of Renton participated in a Corps 2005 Flood Control Project that resulted in gravel removal and construction of floodwalls and levees along the reach of the Cedar River, passing through the City of Renton from River Mile 1.2 to its outlet at Lake Washington at River Mile 0. This substantial flood reduction project protects critical infrastructure important to the regional and state economies, including the Boeing Renton Plant and the Renton Airport.

Cedar River flooding in Renton, 1996

The City of Renton maintains the 205 Flood Control Project structures through an agreement with the Corps. Levees and floodwalls are designed to protect up to the 1 percent annual chance flood. Sediment accumulation is regularly monitored, and periodic dredging is conducted to maintain freeboard at the levees and floodwalls to contain the 1 percent annual chance flood. The most recent dredging was completed in 2016 and was funded by the FCD. The frequency of dredging in the future is expected to be on the order of every 10 to 20 years.

Hydrology and Hydraulics

Most precipitation within the Cedar River basin falls during the fall and winter as snow in the upper elevations of the basin and rain at lower elevations. Seasonally, high-intensity, focused precipitation associated with atmospheric river events, often accompanied by above-average temperatures and melting of the snowpack, has resulted in high rates of runoff and flooding throughout the basin. Most major flooding on the Cedar River has typically occurred during the fall and winter rainy season between October and March.

The magnitude and duration of floods in the Cedar River are driven by runoff from storms, but partially regulated by the City of Seattle's operations of Masonry Dam at the outlet of Chester Morse Lake. Although discharge from the Cedar River is regulated primarily for water-supply operations, limited flood storage capacity exists within Chester Morse Lake during the fall and winter flood season, which is used to reduce flood peaks for downstream communities and limit scour of salmon redds, or nests, within streambed gravels. The city also augments summer low flows for the purpose of supporting salmon runs, consistent with instream flow requirements established under the Cedar River Watershed Habitat Conservation Plan prepared under the ESA (City of Seattle 2000).

While the Masonry Dam was not designed or built to serve as a flood-control dam, it has the capacity to store up to 15,000 acre-feet of floodwater. During the flood season, the dam is operated to maintain a buffer, or "flood pocket," in the reservoir whenever possible so that the peak discharge of floods can be reduced. The effect of this management practice has been a reduction in the magnitude, frequency, and severity of flooding downstream of the dam, while sometimes also increasing the duration of flood peak flows. The dam is neither intended for, nor capable of, holding back high-volume, long-duration, or back-to-back flood events that do not allow adequate time to restore Chester Morse Lake's flood pocket. So, while the dam does provide some limited flood risk reduction benefits under certain circumstances, flood-prone areas downstream remain exposed to severe flood risks.

Flow quantiles represent common flood events based on the percent chance that they will occur in any given year (percent chance exceedance) or the average interval of time that passes between similarly sized flood events (return period). Flow quantiles developed for FEMA floodplain mapping of the Cedar River are listed in **Table 2.3-1**. Projected flows for four different events at two different locations on the river are provided. The flows are based on periods of record from approximately 1920 to 2000 at Landsburg and 1946 to 2000 at

Renton. **Table 2.3-2** and **Table 2.3-3** show recent high flows and the highest flows on record since gage measurements began.

TABLE 2.3-1
FLOW QUANTILES FOR THE CEDAR RIVER

Percent Chance Exceedance	Return Period	Landsburg (cfs)	Renton (USGS Gage 12119000) (cfs)
10	10-year	4,880	5,940
2	50-year	8,340	9,860
1	100-year	10,300	12,000
0.2	500-year	16,100	18,400

TABLE 2.3-2
RECENT HIGH FLOWS, CEDAR RIVER NEAR LANDSBURG GAGE (USGS 12117500)

Date	Flow
2020-02-07	7,590 cfs

TABLE 2.3-3
HIGHEST FLOWS RECORDED AT CEDAR RIVER NEAR LANDSBURG GAGE (USGS 12117500) SINCE GAGE WAS INSTALLED IN 1895

Date	Flows
1911-11-19	14,200 cfs
1906-11-15	12,400 cfs
1990-11-24	10,800 cfs

Ecological Context and Salmonid Use

Physical and ecological processes and habitat in the Cedar River watershed have been substantially altered from historical conditions via hydrologic alterations, land development, and channel modifications. The lower Cedar River contains forested areas, but bank armoring and residential land uses have reduced floodplain connectivity and led to reduced sediment and wood supply, which has simplified instream habitat (WRIA 8 2005). Geomorphic and habitat complexity are low through much of the lower watershed. Large wood volumes are low and fish habitat is dominated by riffles, with few large pools besides lateral scour pools associated with hardened banks (King County 2018).

The Cedar River supports the largest number of natural-origin Chinook in the WRIA 8 basin and is the highest priority spawning and rearing area for WRIA 8 Chinook. The Cedar River is also the primary spawning area for Lake Washington sockeye and steelhead (WRIA 8 2018). The Cedar River is also used by coho, rainbow, and cutthroat trout, and mountain whitefish (King County 2006). The area above Chester Morse Reservoir contains bull trout, who use the lake and tributaries for spawning and rearing (WRIA 8 2005).

Flooding of residential development in the Cedar River floodplain, January 2009

Monitoring indicates that instream juvenile rearing is a limiting life stage in the Cedar River (WRIA 8 2018). However, recent research has shown that constructed habitats in the Cedar River have increased habitat complexity, in turn increasing predicted juvenile Chinook productivity (Hall et al. 2018). Furthermore, a recent study of large wood and habitat-forming processes specific to the Cedar River indicates that levee setback projects over the past two decades have reconnected floodplains and successfully increased wood volume and associated rearing habitat features in the project reaches (King County 2023).

Flood events on the Cedar River can scour salmon redds, an impact that is exacerbated by a lack of sufficient connected floodplains (WRIA 8 2018, City of Seattle 2000). At the same time, SPU manages streamflow to avoid redd scour during the incubation period, if possible, as well as to support adult salmon migration and spawning (WRIA 8 2018).

Where floodplains remain connected or have been reconnected, juvenile salmon can access off-channel habitat to rear and take refuge from flooding, which can also support habitat development. High flows in 2020 dramatically increased floodplain connectivity and low-velocity aquatic habitat area at the site of the Rainbow Bend floodplain reconnection project, compared to data observed in the years prior to flooding (King County 2022). The 2020 event also resulted in avulsions at two sites on the river—Dorre Don and Riverbend—which led to increased low-velocity aquatic habitat.

Flooding supports the recruitment and transport of large wood to the river, which is identified as a key habitat goal for the Cedar River watershed. Reconnected floodplain areas are critical to maintaining recruited wood in the river by providing areas for wood deposition and retention.

Primary Flood and Erosion Hazards and Risks

Flooding and flood damage to property and infrastructure continue to occur throughout the basin. Areas of low-lying floodplain, channel banks, and active gravel bars can be inundated, eroded, or shifted by floodwaters. Flood protection infrastructure built in the last century often relied on design and construction standards that are now outdated, resulting in deterioration of older flood protection facilities. Additionally, extensive development in areas with little or no flood protection, the emergence of new flood hazard areas following major flood events, and an increase in the number of homes and infrastructure in flood hazard areas all contribute to flood risk in the basin.

Flooding in residential areas poses the greatest risk to public safety in the lower and middle Cedar River basins. Even moderate floods can cause high-velocity flows around homes and over sole-access roadways. At approximately a 20 percent annual chance flood, significant overbank flooding and inundation of structures starts to occur. Between a 10 percent and 5 percent annual chance flood, homes, businesses, and infrastructure begin to experience areas of deep, fast flows and damage. Higher flows typically lead to widespread flooding, major safety concerns, evacuations, road closures, and substantial flood damage to structures and property.

The Cedar River Trail, mostly constructed along the historical grade of the Milwaukee Road railroad, follows the river for much of its length and extends from Lake Washington to Landsburg. In many locations, the river abuts the Cedar River Trail, which needs protection due to the presence of a regional fiber optic line buried within the trail prism along part of its length. Just beyond the trail is State Route 169. Protection of these important regional infrastructure assets remains a primary focus of the Cedar River flood hazard mitigation capital program.

King County mapped the channel migration zone in 2015 and 2019 and delineated severe and moderate channel migration hazard areas, including potential avulsion pathways (King County 2015; 2019). Although much of the Cedar River remains a meandering single-thread channel, partial avulsions, constructed side channels, and floodplain reconnection efforts and levee setbacks have begun to restore multi-thread, braided channels. These channels have created greater diversity than single-threaded channels and provide additional flood storage capacity in some reaches of the river. Channel migration continues to present substantial risk along the Cedar River to residential development within the mapped channel migration zone.

The Cedar River is also flanked by numerous steep, landslide-prone hillsides that contribute important sediment to the river but which have also blocked large portions of the channel during past landslide events. Landslides continue to remain a potential threat to floodwater conveyance and pose an additional flood risk. Earthquakes have historically triggered landslides within the Cedar River Valley, including a large landslide at River Mile 5.0 triggered by the 6.8-magnitude Nisqually Earthquake on February 28, 2001, which resulted in channel avulsion and flooding upstream of the landslide.

Landslides and debris flows along steep slopes at the margins of the Cedar River Valley convey sediment to the Cedar River channel throughout its much of its corridor. King County mapped landslides within the Cedar River corridors in 2016 and identified areas of potential deep-seated landslides that are both in contact with the river and large enough to partially or completely block the river channel and affect flooding occurrence and severity (King County 2016). King County also identified smaller landslides and debris flows, which can contribute large amounts of sediment that can impact flooding locally and downstream as sediment is moved and stored within the river channel (King County 2016). It should be noted, however, that landslides are an important source of sediment to the Cedar River that help form and maintain aquatic habitat.

Overview of Sammamish River Basin

The Sammamish River flows 13.8 miles from the weir at the outlet of Lake Sammamish near the City of Redmond to its mouth in Lake Washington at the City of Kenmore, draining 240 square miles of the foothills of the Cascade Range and the Puget Lowland. Major tributaries to the Sammamish River include Bear, Little Bear, North, and Swamp creeks. Issaquah, Tibbetts, and Laughing Jacobs creeks flow into Lake Sammamish upstream of the Sammamish River. Prior to the diversion of the Cedar River to Lake Washington following the construction of the Ballard Locks and the Lake Washington Ship Canal, the Sammamish River was the largest tributary to Lake Washington.

The Sammamish River is a low-gradient river, at present losing about 14 feet in elevation over its 14-mile length. The Sammamish River's floodplain spans much of the valley floor upstream of the City of Woodinville where it occupies a broad valley north of Lake Sammamish but narrows downstream where the valley becomes more confined. The entire river is part of the Sammamish River Improvement Project (SRIP) completed by the Corps in 1964–1966, with King County designated as the local sponsor. The SRIP channelized, dredged, and straightened what was previously a highly sinuous, meandering channel and extensive floodplain wetland network (formerly called the Sammamish Slough). This project connected and completed several earlier piecemeal efforts by King County diking districts and individual landowners to allow the river's floodplain to be developed.

Much of the Sammamish River flows through incorporated areas. Starting at the mouth and moving upstream, the river passes through the cities of Kenmore, Bothell, Woodinville, and Redmond. The middle portion of the river is in unincorporated King County, with most of the land in this area protected for farming uses as an Agricultural Production District. While the valley was once used almost exclusively for agriculture, today a variety of land uses can be found along the river.

The paved, well-maintained Sammamish River Trail lines 10.1 miles of the river. The Sammamish River Trail is a major connection between several other trail and park systems, including the Burke-Gilman Trail to the City of Seattle, Wilmot Gateway Park in Woodinville, Sammamish Regional Park, Willows Run Golf Complex, and the largest active-use park in the King County Park system, Marymoor Park. A trail extension connects the Sammamish River Trail with the East Lake Sammamish Trail via Marymoor Park.

Geology and Geomorphology

Lake Sammamish and the Sammamish River Valley are examples of a glacial trough, carved by sub-glacial meltwater during continental glaciation (Booth 1994). The lake is naturally impounded by the alluvial fan formed at the mouth of Bear Creek. The present-day river is a constructed single-thread channel with a mildly meandering pattern. Landward of the armored riverbanks is a floodplain of young alluvium, wetland deposits, and older terraces.

The historically sinuous channel that meandered through a wide, low-gradient valley bottom with sand and silt substrate is consistent with the glacial trough features seen in the lower Snoqualmie River (Collins et al. 2003). As such, naturally slow rates of lateral channel migration could be expected before the massive alterations that revised the Sammamish River channel and floodplain. With the entire river now channelized and locked in place by bank armoring, there is little likelihood of channel movement.

Hydrology and Hydraulics

Prior to European settlement, Lake Sammamish drained into Lake Washington through the old Sammamish Slough, a highly meandering, low-gradient river bordered by extensive wetlands and floodplains. The meandering course of the Sammamish Slough stretched about 30 miles from Lake Sammamish to Lake Washington and was an important transportation corridor. Following the construction of the Lake Washington Ship Canal and Ballard Locks in 1916 and the accompanying lowering of Lake Washington by 9 feet, the water surface of the Sammamish Slough lowered as well.

Property owners along the slough formed a drainage district to straighten and deepen the channel so that the adjacent lands could be developed for agriculture. Lands along the renamed Sammamish River were converted into agricultural use, but from the beginning they were subjected to almost annual flooding from spring runoff. The Corps completed the river channelization project in 1966, resulting in the present 14-mile course of the Sammamish River.

From Lake Sammamish to its outflow at Kenmore, the river was dredged, which deepened the channel approximately 5 feet and increased the channel width from approximately 15 feet to between 32 and 50 feet. A low weir at the outlet of Lake Sammamish was installed, which marks the upper boundary of the river. The weir outlet slows release from Lake Sammamish during low-flow periods to maintain summer lake levels. During high flows, the weir is completely submerged by the river, acting as an uncontrolled spillway. The SRIP was designed to pass approximately a 2.5 percent annual chance springtime flood, equivalent to a 10 percent annual chance winter storm, over the weir without the water surface elevation in Lake Sammamish exceeding 29 feet.

Manufactured home community along the modified banks of the Sammamish River, October 2022

Flow quantiles represent common flood events based on the percent chance that they will occur in any given year (percent chance exceedance) or the average interval of time that passes between similarly sized flood events (return period). Flow quantiles developed for FEMA floodplain mapping of the Sammamish River are listed in **Table 2.3-4.** Flow quantiles for four different events at two different locations on the river are shown. The flow quantiles were developed by analyzing the timing of flow inputs from various tributaries and are based on a period of record from 1949 to 2009. **Table 2.3-5** and **Table 2.3-6** show recent high flow on the river and the highest Lake Sammamish water surface elevations since gage measurements began.

TABLE 2.3-4
FLOW QUANTILES FOR THE SAMMAMISH RIVER

Percent Chance Exceedance	Return Period	At Mouth (cfs)	Just Downstream of Bear Creek (cfs)
10	10-year	3,950	1,980
2	50-year	4,890	2,420
1	100-year	5,260	2,590
0.2	500-year	6,060	2,970

TABLE 2.3-5
RECENT PEAK FLOW: SAMMAMISH RIVER AT MARYMOOR WEIR (KING COUNTY 51M)

Date	Flow
2020-02-09	1,791 cfs

TABLE 2.3-6
HIGHEST RECORDED LAKE SAMMAMISH LEVELS SINCE GAGE WAS INSTALLED IN 1939, SAMMAMISH LAKE NEAR REDMOND (USGS 12122000)

Date	Flows
1951-02-12	33.44 feet
2020-02-09	31.17 feet

Ecological Context and Salmonid Use

Habitat in the Sammamish River has been dramatically altered from historic conditions. The lowering of Lake Washington and the subsequent straightening, dredging, and bank armoring of the Sammamish River have eliminated connections between the river and its floodplain and wetlands. As a result, both the quantity and quality of aquatic habitats have been reduced (King County 2006).

The Sammamish River is used by ESA-listed Chinook salmon as well as coho, sockeye, and kokanee salmon, and rainbow and cutthroat trout (Kerwin 2001). There are historical accounts of salmonid spawning in the Sammamish River prior to its modifications, but today there is little or no spawning (Mattila, pers. comm., in King County 2006). Thus, the river primarily serves as a migration and rearing corridor for salmon that spawn in streams, such as Bear, Issaquah, Little Bear, North, and Swamp creeks, and a myriad of smaller streams that still retain some salmonid use, mostly for coho salmon and cutthroat trout (King County 2006) and possibly kokanee (Lake Sammamish Kokanee Work Group 2014). These streams provide important opportunities for salmon to disperse and find suitable habitats, and many restoration efforts led by local governments and nonprofits focus on improving the quality and quantity of habitat in these systems.

Riparian areas along the river are largely lacking tall trees, although multiple recent projects (e.g., by the City of Redmond) have re-established native vegetation in select areas. As a result of degraded riparian conditions, large wood recruitment from riparian areas is reduced, which simplifies instream habitat (R2 Resource Consultants 1999; King County 2006). Additionally, the lack of riparian vegetation along the Sammamish River has resulted in extremely high water temperatures in summer and early fall, impacting salmon migration and likely contributing to pre-spawn mortality (King County 2006). Water temperatures that are both lethal and sublethal in the Sammamish River are key constraints on Chinook recovery (WRIA 8 2018).

The Sammamish River is a Tier 1 area under the WRIA 8 Chinook Conservation Plan, as one of the highest priority habitats for protection and restoration (WRIA 8 2018). WRIA 8 habitat goals for the Sammamish River include increasing riparian cover and adding thermal refugia (WRIA 8 2018). These actions would support survival and productivity of salmon spawned in upstream areas by reducing temperature problems and increasing habitat complexity, such as pools and hiding cover, along their migratory pathway. While the engineered nature of the Sammamish River has greatly diminished (and in some cases eliminated) the beneficial functions associated with connected floodplains, some limited areas with connected floodplains do remain that provide habitat benefits. Such areas can be found in the cities of Redmond, Kenmore, and Bothell.

The shallow-water shoreline areas of Lake Sammamish are important for salmon to escape from predation and for feeding as fry (WRIA 8 2017). Most of the lakeshore is privately owned and developed, which has resulted in shoreline armoring and other modifications. Overwater structures along the lake impact prey resources and migration behavior of Chinook salmon and reduce the amount and quality of shallow water habitat (WRIA 8 2005). Predation of juvenile Chinook by native and non-native species in Lake Sammamish is suspected to limit juvenile survival in the watershed (WRIA 8 2017). Other factors limiting salmon in the lake include invasive plant species, elevated water temperatures, low dissolved oxygen, and inadequate riparian buffers (Ecology 2020).

The Lake Sammamish kokanee salmon is a freshwater species that spawns primarily in tributaries to Lake Sammamish and on lake beaches near potential groundwater upwelling areas (Lake Sammamish Kokanee Workgroup 2014). Kokanee rear and mature in Lake Sammamish before returning to the lake's tributaries to spawn, and they are significantly impacted by high water temperatures and low dissolved oxygen. The influence of water temperature and low dissolved oxygen result in severe limits to available habitat for kokanee from April through November (HDR Engineering 2009). Other limits on native kokanee salmon include low egg-to-fry survival due to scour during high-flow events and possibly predation (HDR Engineering 2009). While not listed under the ESA, Lake Sammamish kokanee are in grave decline and face a real risk of extinction.

Primary Flood and Erosion Hazards and Risks

The SRIP significantly reduced the frequency and severity of flooding risks along the Sammamish River and, when flooding occurs, it predominantly affects the agricultural and recreational lands that occupy the wide central floodplain. Completed as part of the SRIP, the 1964 Sammamish River Operation and Maintenance Manual outlines maintenance practices to ensure conveyance of the design flow through the river channel. This includes annual mowing of the banks to keep them clear of all vegetation, as well as occasional dredging or channel clearing to remove any accumulated sediment or wood.

Over time, maintenance practices evolved to reflect the emergence of new environmental regulations and associated regulatory drivers (i.e., listing of salmon as threatened in 1999). In recent years, maintenance practices have shifted away from annually mowing the banks to focus on selective vegetation thinning or removal where needed for flood conveyance. In many locations, the amount of mowing needed to control the invasive plants that dominate the riverbanks is neither practical nor necessary from a flood perspective.

King County and the Corps performed a joint inspection of the full Sammamish River in October 2022. Substantial deficiencies were identified related to scour of rock at the base of the levees, over-steepened banks, and overgrowth of riparian and aquatic weeds. Piping created by mammal burrowing is a significant issue in the City of Redmond and agricultural lands.

A weir at the uppermost end of the river retains water in Lake Sammamish during summer, when the lake sees extensive recreational use. The weir includes a low-flow notch to support passage for migratory fish. Water that leaves the outlet of Lake Sammamish flows across the weir, then through the 1,432-foot-long transition zone into the trapezoidal river channel. Through this transition zone, the river drops 6.75 feet, approximately half the total 14-foot drop over the entire 14-mile river.

In 1998, King County partnered with the Corps to redesign and rebuild the deteriorating weir structure. This work was done in concert with fish passage improvements and extensive bank stabilization and revegetation. The project covered several thousand feet of bank in Marymoor Park. More recently, the City of Redmond designed and built several habitat enhancement projects in the river corridor.

In 2011, the frequency and extent of mowing in the transition zone was increased in response to elevated winter lake levels. In addition, trimming of the willow buffer was increased to maintain a navigation channel and flow conveyance. King County and the Corps are working together to update the 1964 Operations and Maintenance Manual to codify letters of agreement on vegetation management and ensure the manual is consistent with contemporary environmental regulations. The expected completion date is 2024.

In 2022, King County engaged jurisdictions along the river to begin development of the 2024 Sammamish River Capital Investment Strategy and Implementation Plan, which seeks to update the actions recommended in the 2002 Sammamish River Corridor Action Plan (TetraTech 2002) while integrating updates on maintenance requirements related to the Operation and Maintenance Manual update. This Flood Plan is anticipated to be complete later in 2024.

The goal of the SRIP was to protect farms in the valley from spring floods and to maintain a minimum summer water level for Lake Sammamish. The project has consistently met the outflow expectation from lake to the river after March 1 each year. The design of the project also anticipated some winter lakeshore flooding. However, as development in the basin has increased—including development of the lakeshore and development in areas that drain to the lake and river (most notably, in the Bear Creek basin)—lakeshore properties may be seeing impacts that differ from the past. Lakeshore flooding can result in damage to private docks and erosion of lakefront property, with some limited instances of flood damage to residential structures. King County continues to work with property owners and partners, including the King County Flood Control District, to identify appropriate steps to take to address lakeshore flooding through projects and planning activities.

Sammamish River and Bear Creek confluence during heavy rain, February 2020

Overview of the Issaquah Creek Basin

Issaquah Creek runs in a roughly south-north direction and flows from the foothills of the Cascade Mountains to Lake Sammamish. The 61-square-mile basin contains the mainstem of Issaquah Creek and its major tributaries (Holder, Carey, Fifteenmile, and McDonald creeks, and the North and East Forks of Issaquah Creek). Although Tibbetts Creek is not a tributary to Issaquah Creek, it shares a common floodplain in large flood events.

The middle and upper reaches of the basin are in unincorporated King County, and the creek corridor is composed primarily of riparian forest and rural residential development. The lower reaches of Issaquah Creek flow through the highly developed residential and commercial areas of the City of Issaquah before passing through Lake Sammamish State Park, where the creek enters the lake.

Existing land use in the basin includes commercial forests, parks, quarry and mining, residential, commercial, urban, and agriculture. Of the entire basin, 30 percent is zoned commercial forest production and 58 percent is rural zoning. Forests cover more than 68 percent of the entire basin, and commercial forestry continues within the Tiger Mountain

State Forest. The City of Issaquah is the primary urban center and is entirely within the urban growth area.

Geology and Geomorphology

The Issaquah Creek watershed has an hourglass shape with wide valley bottoms both upstream and downstream of a bedrock-controlled constriction located approximately at River Mile 7.3. Squak and Tiger mountains are underlain by bedrock and glacial deposits. The valley floor contains a mixture of glacial sediments and alluvium that consists of reworked glacial and mass wasting deposit materials.

Landslides, including debris flows and shallow to deep-seated slumps, are present throughout the basin. Large landslides and debris flows that may interact with the creek and contribute to flood hazards were identified in the 2016 River Corridor Landslide Mapping (King County 2016). The Issaquah Creek watershed within the City of Issaquah is crossed by the Seattle Fault Zone, an active, east-west-trending regional reverse fault system (the primary fault planes dip to the south and bring land up on the south, while land to the north may drop).

Channel migration zone mapping is under way, and the map should be adopted for land use regulatory purposes in 2024. In general, observations from work completed to date on that study indicate that Issaquah Creek freely migrates at most locations. The riparian area has abundant natural large wood both in channel and available for recruitment. The creek's floodplain is actively engaged in many areas, with a highly mobile bed of sediment that contributes to a high rate of active channel migration. The creek is unregulated by any dams or major water withdrawals. The only exceptions are the Issaquah hatchery weir at River Mile 3.75 and an intake present at about River Mile 4.0 that withdraws creek water used for salmon reproduction. The water intake is protected by grade control structures placed in the channel for about 300 feet downstream of the intake structure. Bank armor is present in many areas along both banks of the creek that locally slows or redirects channel migration but does not prevent it.

Hydrology and Hydraulics

The Issaquah Flood Study is currently being updated. Hydrology for the basin will be reviewed and updated if indicated by analysis of the additional period of record from the previous study to the present. Two USGS gages are present in the basin (12121600 near Issaquah Creek mouth and 12120600 at Hobart, on the bridge at SE 252nd Drive) and have 59 and 36 years of continuous record, respectively.

Flow quantiles represent common flood events based on the percent chance that they will occur in any given year (percent chance exceedance) or the average interval of time that passes between similarly sized flood events (return period). Flow quantiles developed for the effective FEMA floodplain mapping are shown in **Table 2.3-7** and are based on a period of record from 1964 to 1999. Flows for four different events at two different locations on Issaquah Creek are listed. **Table 2.3-8** and **Table 2.3-9** show a recent high-flow event and the highest flows since gage measurements began.

TABLE 2.3-7
FLOW QUANTILES FOR ISSAQUAH CREEK

Percent Chance Exceedance	Return Period	At Mouth (cfs)	At Hobart-USGS Gage 12121600 (cfs)
10	10-year	2,890	2,890
2	50-year	3,700	3,400
1	100-year	3,960	3,560
0.2	500-year	4,490	3,940

TABLE 2.3-8
RECENT HIGH STAGE (HEIGHT) AT ISSAQUAH CREEK NEAR HOBART GAGE (USGS 12120600)

Date	Height
2020-02-06	9.53 ft

TABLE 2.3-9
HIGHEST STAGE (HEIGHT) RECORDED AT ISSAQUAH CREEK NEAR HOBART GAGE (USGS 12120600) SINCE STAGE MEASUREMENTS STARTED IN 1988

Date	Height
1990-11-24	9.9 ft
1996-02-08	9.73 ft

Ecological Context and Salmonid Use

Issaquah Creek is a significant resource for both native and hatchery salmon. Generally, the Issaquah Creek basin includes high-quality aquatic habitat and geomorphic conditions that contribute to habitat diversity within the larger Lake Sammamish-Lake Washington basin (WRIA 8 2005). Issaquah Creek is a Tier 1 area under the WRIA 8 Chinook Conservation Plan, as one of the highest-priority habitats for protection and restoration (WRIA 8 2017).

Middle and upper sections of Issaquah Creek have exceptional fish habitat. Carey Creek and Holder Creek (tributaries to Issaquah Creek) also provide excellent salmon habitat (WRIA 8 2005). Issaquah Creek supports Chinook, coho, kokanee, steelhead, and potentially also bull trout. Issaquah Creek supports a naturally spawning population of Chinook, which is supplemented by hatchery fish that are propagated at the Issaquah hatchery. The hatchery also produces coho and steelhead, and in 2013 fish passage was provided at the hatchery, which restored access to 11 miles of Chinook spawning and rearing habitat. Currently, all tributaries and the mainstem of Issaquah Creek are used by Chinook, although McDonald Creek has low Chinook abundance and infrequent use (WRIA 8 2005). The North Fork and East Fork of Issaquah Creek periodically support late-run spawning of kokanee (Lake Sammamish Kokanee Workgroup 2014).

Water quality in Issaquah Creek is impaired by fecal coliform bacteria. Sources of bacterial contamination in the Issaquah Creek basin include on-site septic systems, possible sanitary sewer line leaks, agriculture, landfills, and wildlife (Ecology 2004). Lack of suitable substrate in the lower section of Issaquah Creek reduces salmonid population capacity, as well as loss of off-channel rearing refugia and lack of large wood (Kerwin 2001). WRIA 8 habitat goals for Issaquah Creek include increasing riparian cover and wood volume (WRIA 8 2017).

Primary Flood and Erosion Hazards and Risks

Flooding impacts from inundation are common in the City of Issaquah, where floods affect commercial and residential properties. The city has identified flooding resulting from insufficient stormwater system capacity or peak flow rates exceeding the normal capacity of the existing conveyance system, which can cause the creek to overtop its banks. Some localized flooding is also caused by the limited capacity of existing stormwater infrastructure or a lack of infrastructure in neighborhoods such as Olde Town (Otak 2021). Most structural flooding occurs because of development located within the floodplain.

Erosion from Issaquah Creek flooding, January 2021

In unincorporated King County, lowland and localized flooding occurs along middle Issaquah Creek, and flooding also occurs along East Fork Issaquah Creek and McDonald Creek. Channel migration can cause bank failures, undermine roads, and result in road closures of extended duration until they are repaired. Channel migration from the 2020 and 2022 flood events caused bank erosion that impacted private property and several residences in the middle and upper basin. Several small bridges are at or nearing their functional design life and at risk from channel migration of debris accumulations on bridge piers and abutments. Steep drainages on the west slope of Tiger Mountain experience high flows with high sediment loads that impact downstream channels, habitat, and road culverts.

Issaquah-Hobart Road SE plays a key regional mobility role in the county's transportation system. The road is impacted by major storm events, and debris flows from tributary drainages can block culverts under Issaquah-Hobart Road SE and result in temporary road closures. Erosion of road embankments is also a concern in multiple places.

Potential Impacts from Climate Change and Other Future Changes

Because analyses of future flows in the Cedar and Sammamish rivers have not been completed, analyses completed for the Snoqualmie and Green rivers can be used to provide some insights into what to expect for the Cedar and Sammamish rivers. By the 2080s, average streamflow for October through March is projected to increase by approximately 10 to 30 percent for these river systems, relative to the 1970–1999 average. Changes in peak flows are influenced by both the declines in snowpack and by higher intensity heavy rain events. The decline in snowpack is projected to have a corresponding decrease in the average summer flow. Because of the variability in basin characteristics across the county (e.g., elevation, snowpack area, and dam management), extrapolating these results to the Cedar and Sammamish rivers should be done with caution until the basin-specific analyses can be completed (Lee et al. 2018).

Cedar River

Larger and more frequent floods resulting from increased winter streamflow may increase the risk of bank erosion, channel migration, damage to levees and revetments, and damage to the private and public infrastructure they protect. Except for the levees along the lower 2.5 miles of the Cedar River, most of the flood facilities in the basin are revetments or training levees that do not provide containment for moderate flood events. This makes floodplain areas along the Cedar River susceptible to flood impacts from increased winter streamflow. Larger and more frequent floods increase the chance for communities to be cut off and isolated by road flooding.

An increase in the frequency, size, or duration of high-flow events on the Cedar River could have mixed effects on riverine functions. Increased high-flow events could create or sustain off-channel habitats in reconnected floodplain areas that rely on floods to keep side channels open and/or recruit large wood. Conversely, in confined channel areas, redd scour could worsen or occur more frequently. Additionally, the anticipated reduction in summer flows will shrink available habitat areas and negatively impact migrating adult and juvenile salmonids in the Cedar River.

Sammamish River

More work is needed to understand the impacts of climate change on flooding along the Sammamish River and Lake Sammamish, but it is conceivable that climate change will result in additional risk in both locations.

This basin may be particularly susceptible to impacts on salmon populations. Increasing water temperatures associated with climate change will negatively impact migrating adult and juvenile salmonids in the Sammamish River, and high water temperatures can cause pre-spawn mortality, block migration, drive egg abnormalities, increase susceptibility to parasites or disease, or change patterns of predation or prevalence of warm-water predators (WRIA 8 2018). Increasing development in the basin may increase the flashiness of high-flow events, which could increase the frequency and/or intensity of redd scour events that may limit productivity of kokanee that spawn in tributaries to the Sammamish River.

Issaquah Creek

Larger and more frequent floods from increased winter streamflow may impact Issaquah Creek in similar ways as described for the Cedar River in terms of damage to levees, revetments, and private and public infrastructure. The City of Issaquah may experience larger and more frequent impacts from flooding, particularly in the downtown area, where flooding could be exacerbated by the overwhelmed stormwater system.

Risk Assessment

A flood hazard risk assessment using Hazus evaluated the effects of flooding on more than 390,000 total structures in the Lake Washington/Cedar/Sammamish Watershed. This analysis revealed the following:

- In the entire watershed, 1,307 structures were found to be exposed to the 10 percent annual chance flood, 1,808 structures were found to be exposed to the 1 percent annual chance flood, and 4,160 structures were determined to be exposed to the 0.2 percent annual chance flood.
- Of the 3,651 critical facilities located in the watershed, 110 would be exposed to the 10 percent annual chance flood, 138 would be exposed to the 1 percent annual chance flood, and 196 are exposed to the 0.2 percent annual chance flood event.
- Of the 35 repetitive loss structures, 24 would be exposed to the 10 percent annual chance flood, 26 structures would be exposed to the 1 percent annual chance flood, and 28 are exposed to the 0.2 percent annual chance flood event.

Following from the exposure analysis, Hazus generated potential flood damages in the watershed, which are illustrated in **Table 2.3-10** for three different return intervals.

TABLE 2.3-10
SUMMARY RESULTS FROM HAZUS ANALYSIS OF POTENTIAL RIVERINE FLOOD DAMAGES IN THE LAKE WASHINGTON/CEDAR/SAMMAMISH WATERSHED

Percent Chance Exceedance	Return Period	Potential Structure and Contents Damage – All Structures	Potential Structure and Contents Damage – Critical Facilities
10	10-year	$2,271,454,913	$4,450,492
1	100-year	$4,732,706,045	$1,137,685
0.2	500-year	$9,904,063,406	$6,304,589

2.4 Green/Duwamish River Watershed

Watershed at a Glance – Green/Duwamish River Watershed

WRIA	• WRIA 9
River systems/reaches included	• Upper Green River • Middle Green River • Lower Green River • Duwamish River
Basin size	• 483 square miles
Key tributaries	• Gilliam, Johnson, Midway, Newaukum, Mill (Kent and Mill Auburn), Soos, and Springbrook creeks; Mullen Slough; Black River
Dams/major infrastructure	• Howard Hanson Dam • Extensive levee system in lower Green (approximately 28 miles of levees and revetments) • Several pump stations, including Black River
Major flood years	• 1946, 1959, 1996, 2009, 2015, 2020
Key issues in the basin	• Water quality, in particular, water temperature • Legacy effects of extensive engineering modifications in the watershed, including flow modifications • Extremely limited floodplain connectivity in lower Green River
Salmonid species present	• Chinook, coho, chum, and pink salmon; steelhead; bull trout; cutthroat trout
Estimated economic damage from a 1 percent annual chance flood	• $356,558,306

Overview

The Green/Duwamish River flows northwest about 93 miles from its headwaters in the Cascade Range to its outlet in Elliott Bay. The Green/Duwamish River basin drains 483 square miles and is bounded on the north by the Cedar-Sammamish watershed and on the south by the White-Puyallup watershed. The Green/Duwamish River basin is entirely within King County. The river flows through several cities, primarily in its lower reaches, including Auburn, Kent, Renton, Tukwila, and Seattle.

The Green/Duwamish River basin is often considered to have four subbasins:

- **The upper Green River** extends from the Cascades downstream to Howard Hanson Dam at River Mile 64.5. The upper basin is a protected watershed with limited access to protect drinking water supply. There is no development, but commercial timber harvest has occurred throughout this portion of the watershed.
- **The middle Green River** extends from the outlet of the Green River Gorge at River Mile 45 near Flaming Geyser State Park downstream to Auburn at River Mile 32. Major tributaries include Soos and Newaukum creeks.

- **The lower Green River** extends from River Mile 32 in Auburn around State Route 18 downstream to the Duwamish River at River Mile 11, near Interstate 405 (I-405). Mill Creek-Auburn, Mullen Slough, and Mill Creek-Kent are major tributaries in the lower Green River. Springbrook, Gilliam, Midway, and Johnson creeks are also in the lower Green River subbasin.
- **The Duwamish River** extends from River Mile 11 downstream to Elliott Bay. The Black River enters the Green River at River Mile 11 and conveys flows from Springbrook Creek and drainage from the right (eastern) bank of the lower Green River. Most of the Duwamish River is tidally influenced.

The lower Green/Duwamish River Valley is comprised of extensive commercial, industrial, and residential development, some agricultural lands around Auburn and Kent, regional transportation infrastructure, and a network of recreational trails and parks that support a vibrant economic base, where approximately 200,000 people live and work. This development was made possible by the construction of Howard Hanson Dam and the levee system that lines most of the riverbanks of the lower Green and Duwamish rivers, which combine to reduce flooding in the lower river to a fraction of its historical magnitude. Nonetheless, these areas continue to face flooding risk, and flood risk reduction in the lower watershed is inextricably linked to the multitude of human actions and land uses within the floodplain. In addition, these modifications have affected floodplain, aquatic, and riparian habitats, which, in turn, have affected salmon populations in the basin, including listed Puget Sound populations of Chinook salmon and steelhead under the ESA.

In the middle Green River watershed, agriculture and rural residential development are the primary land uses, with significant acreage in Agricultural Production Districts. There are also sizable areas of commercial forest lands, in addition to areas of protected open space owned by King County and Washington State Parks.

Input on Flooding in the Green/Duwamish River Watershed

Input on the Green/Duwamish River watershed primarily focused on the lower Green River and Duwamish Waterway. These river reaches are highly modified and have intensively developed floodplains, which present a high concentration of people and property at risk of flood impacts. Coastal flooding and sea level rise impacts were frequently noted as an increasing concern in tidally influenced reaches of the river. Partners and community members shared a range of views, concerns, and interests about flooding in this watershed. Some expressed a desire for enhanced flood protection for industrial and commercial land uses, and others raised concerns of pollution and public health impacts from flooding on the lower Green and Duwamish rivers. Several parties commented on the public health impacts of flooding in the South Park neighborhood along the Duwamish, which relies on a combined sewer overflow system that can back up into residential basements during floods. Others highlighted the ecological impacts associated with the extensive use of structural flood control measures on the lower Green River and Duwamish Waterway, and comments shared that these structures may not be able to withstand climate impacts and accommodate higher floodwater volumes.

Geology and Geomorphology

The Green River flows from its steep headwaters in the Cascade Range, through a narrow gorge and valley it carved in the Puget Lowland, to a broad, low-gradient valley eroded by subglacial runoff. The subbasins of the Green River are largely defined by the geomorphic processes that contributed to their formation.

- The upper Green River, upstream of Howard Hanson Dam, flows through bedrock valleys and is bounded downstream by the western margin of the Cascades.
- The middle Green River flows from the Cascade margin through a narrow gorge and valley the Green River carved into the Puget Lowland.
- The lower Green and Duwamish rivers flow through a broad, low-gradient valley carved by subglacial runoff.

The middle Green River established its present course by eroding unconsolidated glacial sediments and older bedrock. Downstream of the Green River Gorge, the middle Green River has maintained active migration, although channel migration rates have decreased since the construction of Howard Hanson Dam and accompanying flow regulation began in the 1960s (Perkins 1993).

The lower Green River Valley was initially a shallow marine embayment of Puget Sound, but the Osceola Mudflow redirected the sediment-laden White River into the lower Green River. This formed a large alluvial fan at Auburn and caused progressive northward movement of the lower Green River Valley above sea level (Crandell 1963; Dragovich et al. 1994).

Following a flood in November 1906, the White River was permanently redirected southward to the Puyallup River. This diversion removed the main sediment supply of the Green River, reduced the area of the Green/Duwamish watershed by 50 percent, and reduced flood discharges and baseflow within the lower Green River. The abandonment of the Black River following the lowering of Lake Washington in the early 1900s further reduced the area of the Green/Duwamish watershed to 30 percent of its historical size. Regulation of the Green River by Howard Hanson Dam in 1961 further reduced peak-flood magnitudes.

The single-threaded, meandering characteristic of the lower Green River was established prior to diversion of the White River and flow regulation by Howard Hanson Dam. Prior to its diversion, high sediment loads from the White River were deposited as natural levees adjacent to the channel. This deposition also elevated parts of the floodplain in the low-gradient Green/Duwamish Valley with features called alluvial ridges (Collins and Montgomery 2011). By the early 1900s, artificial levees were built on top of these natural levees, thus maintaining the early-1900s characteristics of the lower Green and Duwamish rivers through the present. The lower Green River adjusted its morphology, including its channel width, to a decreased peak flow regime that resulted in channel narrowing (Collins and Sheikh 2005).

Green/Duwamish River overbank flooding (left) and levee containment of floodwaters (right) in Auburn, 1996

Channel geometry throughout the lower Green River has been simplified, and bankfull width increases only slightly in the downstream direction. Actively managed levees and revetments from River Mile 32 to River Mile 11 confine the lower Green River channel and limit channel migration. Channel confinement within the lower Green River has steepened channel banks and increased streambed erosion and incision, particularly at outside bends. Over the last several decades, streambed erosion caused widespread lowering of the channel floor from 1 to 2 feet. Channel bed incision is typically exacerbated by the presence of levees and revetments that harden the banks, thereby preventing lateral slope erosion and thus increasing stress along the toe of levees (King County 2019).

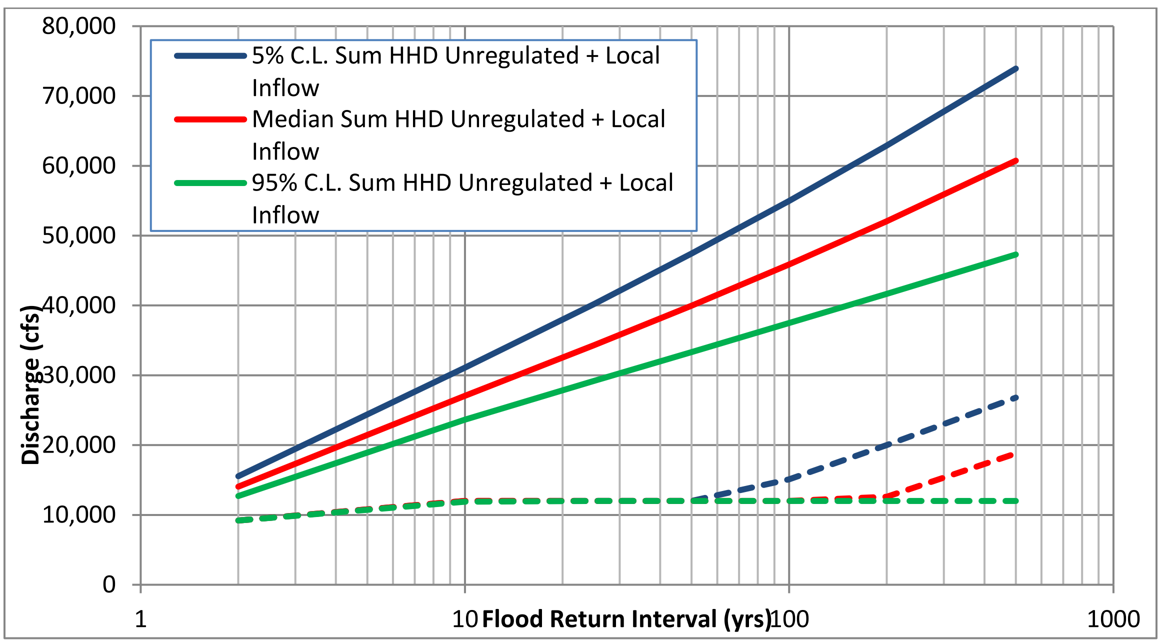
Hydrology and Hydraulics

Major flood events on the Green River generally occur between November and February. Flood conditions are primarily influenced by the operation of Howard Hanson Dam. During a flood event, outflows from Howard Hanson Dam are regulated based on the hydrologic conditions at a downstream control point at the USGS gage at Auburn.

Howard Hanson Dam and the Green River's system of levees and revetments work together to reduce flood risks to the lower Green River Valley. The dam regulates outflows from the reservoir to target a maximum of 12,000 cfs as measured at the Auburn gage (RM 31.0) for most flood events. This target regulated flow rate at Auburn represents the approximate channel capacity of the leveed portions of the lower Green River Valley. Land use in this area was developed with the general understanding that flood management regulation at Howard Hanson Dam could maintain the target flow of 12,000 cfs at Auburn up to the 0.2 percent annual chance flood (equivalent to a 500-year event). However, a 2012 Corps study concluded that the dam is capable of maintaining the 12,000 cfs target flow only for events up to a 0.7 percent flood (equivalent to a 140-year event).

Operations at Howard Hanson Dam must consider the magnitude and timing of local inflows from tributaries below the dam, such as Soos and Newaukum creeks. The 12,000 cfs target flow is the medium annual exceedance probability for the 10 percent to 1 percent annual chance floods. The median flow for a 0.5 percent annual chance flood is 12,600 cfs, and 18,800 cfs for the 0.2 percent annual chance flood.

The high degree of flow regulation provided by Howard Hanson Dam results in most of the flood hydrographs having peaks at or very close to 12,000 cfs, although the total flood volumes and peak flow durations vary widely. The discharge is shown in **Figure 2.4-1** and the variation in flood volume is reflected in **Table 2.4-1** as the duration in days that the flows are kept at an elevated level to evacuate the reservoir. Table 2.4-1 also includes a range of flows in addition to the median expected peak flow to reflect uncertainty (high and low confidence limits) for each flood. The significance of flood volume is also reflected in the stage-discharge curves. There is a more-than-1-foot difference in the maximum channel water surface elevations between 11,900 cfs and 12,600 cfs, which can result in significant differences in the extent of inundation in the event of levee failures or levee overtopping (King County 2019). **Table 2.4-2** and **Table 2.4-3** highlight recent high flows and the highest flows recorded on the Green River.



Source: Corps 2012

Figure 2.4-1
Discharge vs. Annual Exceedance Probability & Flood Frequency at Auburn

TABLE 2.4-1
SIMULATED REGULATED FLOW AT AUBURN GAGE (USGS GAGE 1211300), CORPS OF ENGINEERS (2012)

Flood Event	Confidence Level	Regulated Peak Flow (cfs)	Approximate Duration Above 12,000 cfs (days)	Approximate Duration Above 10,000 cfs (days)
0.2% AEP Flood (500-year)	Median	18,800	3.8	> 13
	High Confidence Limit (5%)	26,800	4.3	>13
	Low Confidence Limit (95%)	12,000	0	11
0.5% AEP Flood (200-year)	Median	12,600	3.2	>13
	High Confidence Limit (5%)	20,000	4.3	>13
	Low Confidence Limit (95%)	12,000	0	9.4
1% AEP Flood (100-year)	Median	12,000	0	11
	High Confidence Limit (5%)	15,100	2.6	>13
	Low Confidence Limit (95%)	12,000	0	7.5
2% AEP Flood (50-year)	Median	12,000	0	9
	High Confidence Limit (5%)	12,000	0	11.7
	Low Confidence Limit (95%)	12,000	0	6.3
4% AEP Flood (25-year)	Median	12,000	0	5.7
	High Confidence Limit (5%)	12,000	0	8.9
	Low Confidence Limit (95%)	12,000	0	4.5
10% AEP Flood (10-year)	Median	12,000	0	3.5
	High Confidence Limit (5%)	12,000	0	5.7
	Low Confidence Limit (95%)	11,900	0	2.8
50% AEP Flood (2-year)	Median	9,200	0	0
	High Confidence Limit (5%)	9,900	0	0
	Low Confidence Limit (95%)	9,200	0	0

Note: The shaded cells indicate those flood events with peak flows greater than the target flow rate at Auburn.

TABLE 2.4-2
RECENT HIGH FLOWS AT GREEN RIVER NEAR AUBURN GAGE (USGS 12113000)

Date	Flows
2020-11-07	11,700 cfs
2015-12-09	10,900 cfs

TABLE 2.4-3
HIGHEST FLOWS RECORDED AT GREEN RIVER NEAR AUBURN GAGE (USGS 12113000) SINCE PEAK MEASUREMENTS AT THE GAGE BEGAN IN 1937

Date	Flows
1959-11-23	28,100 cfs
1946-12-11	22,000 cfs
1955-12-12	20,300 cfs

Ecological Context and Salmon Use

The middle Green, lower Green, and Duwamish rivers span a wide array of river and estuarine conditions, ranging from moderate-gradient, gravel-bedded channel segments in the middle Green River to a low-gradient, single-thread, silt- and sand-bedded channel, followed by a mix of armored and unarmored banks in the lower river and estuary areas as the river empties into Elliott Bay.

The modification and diversion of river flows, channelization, removal of vegetation, and construction and operation of levees and other flood protection infrastructure supported growth and economic development in much of the lower watershed. However, these changes have negatively affected floodplain, aquatic, and riparian habitat and water quality, which, in turn, have negatively affected salmon populations in the basin, including Puget Sound populations of Chinook salmon and steelhead listed as threatened under the ESA. The present-day lower Green/Duwamish River is highly engineered and characterized by confined channels lined with bank armoring. In this condition, instream complexity and floodplain connectivity are significantly limited.

Along most of the lower Green and Duwamish rivers, the constraints presented by levees and revetments result in hydraulically simplified, flume-like conditions, a lack of large wood, and little potential for wood recruitment. There is little or no connection between the river and its floodplain habitats, except in cases where recent floodplain reconnection projects have occurred (e.g., Downey Farmstead, Lower Russell, and Riverview Park in Kent and Duwamish Gardens, and Chinook Wind in Tukwila). Human activities have nearly eliminated the shallow, slow-water edge, side channel, and wetland habitats that originally existed along the lower Green River, and the habitat that does exist is of low quality. As a result, the river sees high mortality of juvenile salmonids.

McCoy Levee on the Green/Duwamish River in Kent, 2021

Vegetation in the lower Green and Duwamish rivers is predominantly invasive (e.g., blackberry, reed canarygrass, Japanese knotweed), aside from some patches of native trees and levee repair sites that incorporated vegetation as a bank stabilization design element. Riparian areas lack mature trees, resulting in minimal shade and elevated water temperatures. Existing water temperatures and dissolved oxygen do not meet water quality standards, and high water temperatures can reach lethal levels for salmonids during hot summer days (Ecology Total Maximum Daily Load [TMDL]). The lack of riparian trees and shrubs also reduces available food resources for juvenile salmonids.

The middle Green River subbasin includes the Green River's best salmonid habitat and is where most of the watershed's salmonid spawning occurs. Development is far less dense, and riparian and floodplain areas are much less constrained by development than in the lower portion of the watershed. The subbasin has some heavily confined reaches with levees and unconfined channels that have little or no bank armoring, active channel migration, and well-connected side channels. This portion of the watershed also contains Soos and Newaukum creeks, the two largest and most influential tributaries (Martin et al. 2004). Recently completed floodplain reconnection projects in the middle Green River that provide substantial habitat enhancement include the Čakwab Levee Setback and Porter Reach Restoration Project.

Marking the transition to the upper watershed, Howard Hanson Dam exerts a strong influence on ecological conditions downstream by stopping the passage of sediment and large wood, altering seasonal temperature and flood flow regimes, and preventing fish passage into the upper watershed (Kerwin and Nelson 2000). The dam traps coarse sediment and large wood from upstream sources and prevents their transport to reaches below the dam. By removing these building blocks for downstream habitat, the dam contributes to the loss and simplification of mainstem and side channel habitat in the middle and lower Green and Duwamish rivers.

Habitat limitations have led to a serious long-term decline in the Green River Chinook salmon population. The recent 5-year average (2015–2019) of 1,822 natural-origin spawners remains a fraction of both the historical population estimate of 37,700 and the recovery target of 27,000 (Shared Strategy 2007; Ford et al. 2022). A limiting factors analysis completed in 2000 as a precursor to the 2005 WRIA 9 Salmon Habitat Plan found that disconnection of the lower Green River from its floodplain and the subsequent loss of juvenile rearing and refuge habitat is one of the most significant factors affecting salmon. The lack of low-velocity habitat forces many juvenile salmon to migrate to Puget Sound prior to obtaining adequate growth, greatly reducing their chances for survival.

Throughout the watershed, roughly 80 percent of the historic Green/Duwamish floodplain is entirely cut off from the river. This equates to almost 25 square miles that will no longer flood and are thus no longer accessible to fish during the key juvenile rearing and outmigration period. The WRIA 9 Watershed Ecosystem Forum, in partnership with numerous other partners and funders, has pushed the completion of 34 habitat restoration projects by 2023, most of which address primary habitat limiting factors (M. Goehring, personal communication, 2023). Many other projects to address habitat deficiencies in the Green River have been proposed as part of the WRIA 9 2021 Habitat Plan Update.

The Green River System Wide Improvement Framework (SWIF) assessed aquatic, floodplain, and riparian habitat for reaches within the lower Green River. The evaluation was completed to highlight regional considerations related to habitat and environmental compliance that must be addressed as part of levee management. The assessment is intended to inform habitat restoration opportunities, levee vegetation management, and capital project design, with a focus on instream and riparian habitat enhancements and water quality improvements that would benefit salmonids.

Additionally, the U.S. Congress recently authorized $878.5 million to construct a juvenile fish passage facility through the Howard Hanson Dam (Tacoma Water previously built a trap-and-haul facility to transport adult salmon above the dam). Once completed in approximately 2030, salmon will have access to nearly 100 miles of additional habitat above the dam (TPU 2023).

Primary Flood and Channel Migration Hazards and Risks

Even with the dam and extensive flood protection infrastructure, flood risk continues to be a concern in the river corridor and valley. The extent of development in the floodplain and the large number of people who live, work, and transit through the lower valley mean that the potential impacts of major flooding on structures, infrastructure, the economy, and the public are substantial. Industrial, commercial, and residential development; highways, roads, utilities, and other critical infrastructure; agricultural operations; and more are subject to flood risk. With a 0.2 percent annual chance flood event (18,800 cfs), approximately 7,400 acres of the lower valley would be inundated from less than 1 foot to 6 to 10 or more feet in depth. **Figure 2.4-2** presents a composite of shoreline overtopping scenarios, generated from running the Green River Flood Model, using different flow rate scenarios (King County 2019).

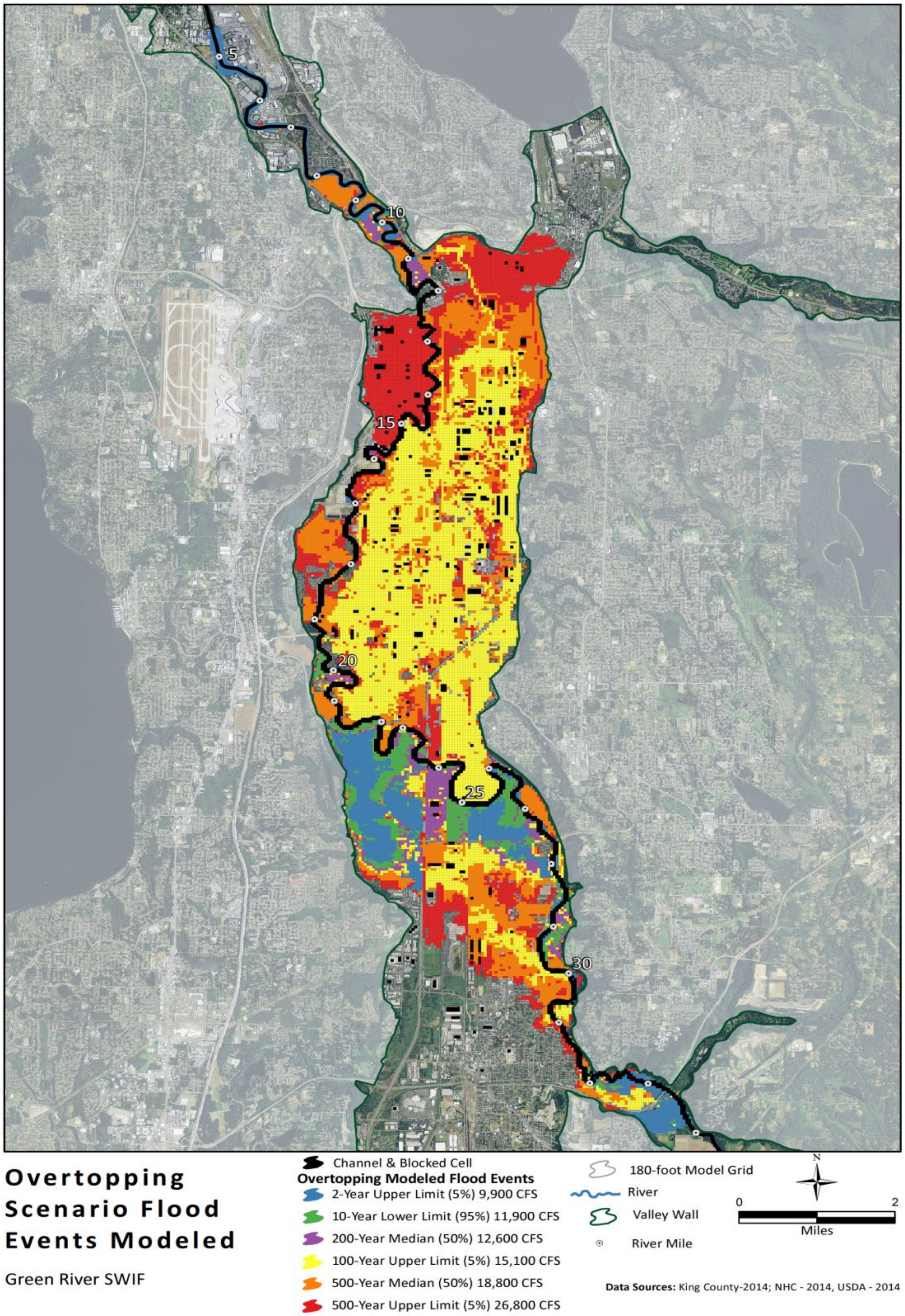


Figure 2.4-2
Overtopping Scenario Flood Events

The Duwamish River faces combined risk from upstream, freshwater inputs and downstream coastal and tide-related factors. The South Park neighborhood along the Duwamish River was impacted by significant flooding in December 2022 and January 2023 because of a combination of stormwater runoff, snowmelt-driven river flow, high groundwater, and record king tides. Areas like the lower Duwamish River are subject to a variety of natural processes that present significant hazards to public safety and property, including storm-surge flooding, waves, erosion, rainfall, and wind.

Flooding of South Park neighborhood in Seattle near mouth of Green/Duwamish River, December 2022

The lower Green River levees and existing unarmored shorelines provide variable levels of protection. Bank overtopping can occur in some locations during a 50 percent annual chance flood or 9,000 cfs event, while other armored shoreline locations are protected to upwards of 18,800 cfs, the median 0.2 percent annual chance flood event. River channel conveyance capacity for flows over 12,600 cfs (median 50 percent annual chance flood event) and the extent and depth of inundation of the floodplain and developed areas vary widely depending on the levees and floodplain conditions (King County 2019).

The magnitude and frequency of flood events and the condition of the levee system contribute to risk. While many levee rehabilitation projects have been completed in the lower Green subbasin, levees that do not meet current construction standards continue to present risk. Portions of the levee system in the lower Green River do not meet the Corps' recommended factors of safety, a common measure of engineering safety. For levees and revetments that have not been recently improved, many have over-steepened banks, areas with inadequate or deteriorating rock buttressing at the embankment toe, and incrementally slumping or sloughing riverbank slopes supporting constructed earthen levee berms. Beyond this instability, the potential for liquefaction during an earthquake is a primary concern.

While Howard Hanson Dam significantly reduces flood peaks, it results in longer durations of elevated flows. With flows confined to a narrow, leveed channel, the potential for flood scour of the riverbed is significant. Where this occurs, undermining and deterioration of the embankment toe of levees has been observed, especially on the outside of river bends. Such conditions can stress the levee and revetment system and potentially increase the occurrence and magnitude of slump failures. An evaluation of levee repair locations showed that greater than 5 feet of channel bed incision is associated with a substantial risk of future damage to adjacent levees and revetments (King County 2019).

Rapid changes in dam releases, especially a decrease in outflows, can lead to rapid drawdown of hydrostatic pressure on the river side of a levee. High pore pressure within the levee prism due to saturated soil conditions can lead to riverbank slumping that can damage the integrity of the levee core. As a result, many Green River levees require frequent maintenance, and nearly all have been identified as needing rehabilitation so that they are better suited to provide protection.

Levees and revetments along the middle Green River are scattered, discontinuous, and largely deteriorating. They are not designed to contain flood flows or prevent inundation, but rather to direct high flows and inhibit channel migration that impacts rural residential and agricultural land use. These discontinuous levees and revetments will continue to experience lateral channel migration and channel avulsion. In some locations, broad meanders and braiding channels are constantly shifting within a complex of active gravel bars, vegetated riparian floodplains, and remnant side channels.

The upper Green River basin (above Howard Hanson Dam) and portions of the middle Green River have a medium/high intermix areas (where structures and vegetation are mingled). King County mapped landslides within the river corridors, including the middle Green, in 2016 and identified areas of potential deep-seated landslides that are both in contact with the river and large enough to partially or completely block the river channel and affect flooding occurrence and severity (King County 2016). King County also identified smaller landslides and debris flows, which can contribute large amounts of sediment that can impact flooding locally and downstream as sediment is moved and stored within the river channel (King County 2016). Post-wildfire flooding, landslides, and mudslides pose a secondary hazard from extreme wildfires in areas with steep slopes. Soils in areas burned by fire not only lose their stabilizing vegetation but can also become hydrophobic (water repelling), leading to massive water runoff that carries debris down slopes and into nearby waterways. Post-fire flooding is a serious threat to King County, including portions of the middle and upper Green River (OEM 2020).

Potential Impacts from Climate Change and Other Future Changes

By the 2080s, average streamflow for October through March is projected to increase by 10 to 22 percent for the Green River near Auburn (USGS ID: 12113000), relative to the 1970–1999 average. Changes in peak flows are influenced by both the declines in snowpack and by higher intensity heavy rain events (Lee et al. 2018).

The lower Green/Duwamish basin will continue to be developed, with much of that development occurring within the 0.2 percent annual chance floodplain. Impacts from climate change are expected from increased runoff in the basin, particularly from tributaries and creeks such as Soos, Mill, and Springbrook creeks, which are all expected to experience substantially increased flows with climate change. In the lower portion of the watershed, changes in sea level and climate change further increase the potential impact of coastal hazards and compound flooding.

The Black River Pump Station was constructed in 1972 to address numerous drainage and river alterations. The pump station provides an outlet for Springbrook Creek and serves as a dam to keep high tides and Green River floods out of Renton and parts of Kent and Tukwila. The pump station may be impacted with sea level rise, changes in tidal influence area, and saltwater intrusion.

Risk Assessment

The flood hazard risk assessment using Hazus evaluated the effects of riverine flooding on more than 260,000 total structures in the Green/Duwamish watershed. While Hazus used the most current flood depth information available from FEMA, it is important to note that this analysis was not nearly as detailed as the modeling conducted for the Green River SWIF. Furthermore, inconsistencies in the FEMA flood insurance study data resulted in higher exposure values for the 1 percent annual chance riverine flood than the 0.2 percent annual chance riverine flood. Despite these limitations, Hazus provides useful approximations for understanding potential risk in the watershed, and the analysis revealed the following:

- In the entire watershed, 730 structures were found to be exposed to the 10 percent annual chance flood, 3,481 structures were found to be exposed to the 1 percent annual chance flood, and 3,783 structures were found to be exposed to the 0.2 percent annual chance flood.

- Of the 3,109 critical facilities located in the watershed, 80 would be exposed to the 10 percent annual chance flood, 148 would be exposed to the 1 percent annual chance flood, and 156 are exposed to the 0.2 percent annual chance flood.
- None of the 11 repetitive loss structures would be exposed to the 10 percent annual chance flood, and three would be exposed to the 1 percent annual chance flood and to the 0.2 percent annual chance flood.

With the numbers of structures identified as exposed to flooding, Hazus generated estimates of potential flood damage. **Table 2.4-4** illustrates potential flood damages for three return intervals.

TABLE 2.4-4
SUMMARY RESULTS FROM HAZUS ANALYSIS OF POTENTIAL RIVERINE FLOOD DAMAGES IN THE GREEN/DUWAMISH RIVER WATERSHED

Percent Chance Exceedance	Return Period	Potential Structure and Contents Damage – All Structures	Potential Structure and Contents Damage – Critical Facilities
10	10-year	$17,674,045	$80,429,034
1	100-year	$156,539,380	$94,022,126
0.2	500-year	$111,136,841	$93,983,398

2.5 White River Basin

Watershed at a Glance – White River Watershed

WRIA	• WRIA 10
River systems/reaches included	• Upper White River • Middle White River • Lower White River • Greenwater River
Basin size	• 490 square miles
Key tributaries	• Greenwater River and Boise Creek in King County, and the Clearwater River, West Fork White River, and Huckleberry Creek in Pierce County
Dams/major infrastructure	• Mud Mountain Dam • Buckley Diversion Dam and Fish Passage Facility
Key flood years	• 1932, 1933, 2009, 2021, 2022
Key issues in the basin	• High sediment load from Mount Rainier • Development located in depositional reach • Diminished channel capacity
Salmonid species present	• Chinook, chum, coho, and pink salmon and bull trout, coastal cutthroat trout, and steelhead
Estimated economic damage from a 1 percent annual chance flood	• $8,826,812

Overview

More than 100 years ago, the White River was diverted to flow into the Puyallup River in Pierce County. Inclusive of King and Pierce counties, the White River drainage includes the Greenwater River, West Fork White River (entirely within Pierce County), upper White River (entirely within Pierce County), Middle White River, Clearwater River, Red Creek, Boise Creek, and lower White River drainage basins. The White River drains an area of about 490 square miles, approximately one-third of which lies within King County. Mud Mountain Dam, constructed by the Corps in the 1940s, provides flood protection to the lower White and Puyallup river valleys.

The King and Pierce county boundary passes through the cities of Pacific and Auburn and then follows the White and Greenwater rivers as they existed in 1852, when Pierce County was formed by the Oregon Territory legislature. Areas along the river are densely developed through the cities of Sumner, Pacific, and Auburn. Upstream of Auburn, the floodplain is mostly undeveloped and contained within a canyon incised into glacial deposits. The upper portion of the watershed is primarily forested and protected within Mount Rainier National Park, with the middle portion of the watershed containing agricultural land and the southern portions of the City of Enumclaw. The Muckleshoot Reservation, as well as some off-reservation tribal lands, are located along the lower portion of the White River, which flows through the cities of Auburn and Pacific before entering Pierce County.

Input on Flooding in the White River Watershed

Community members and partners submitted less input about flooding in the White River watershed than the other watersheds of the county. The feedback provided identified a need for more information about emergency response and evacuation resources and an interest in maintenance of the White River channel through dredging and removing instream wood. Partners also shared information about tributary flooding concerns in and around the City of Enumclaw that are arising due to channel changes, which affect residential neighborhoods, city streets, and the city's sanitary sewer system.

Geology and Geomorphology

The White River basin is geologically very young. It extends from the peak of Mount Rainier to the Puget Lowland, with headwaters that drain slopes of volcanic bedrock and glacially scoured terrain. Multiple episodes of continental glaciation that covered the Puget Lowland shaped much of the lower river valley, while glacial and volcanic processes have shaped the middle and upper river valleys.

About 5,600 years ago, the Osceola Mudflow, a clay-rich lahar from an eruption on Mount Rainier, flowed down the north flank of the volcano, filled the White River Valley, and spread out over the glacial troughs and outwash plains of the Puget Lowland. Prior to the Osceola event, the White River flowed southwest out of the Cascade Range foothills along the path of present-day South Prairie Creek to a confluence with the Carbon and Puyallup rivers. The White River carved a new channel through the Osceola deposit and underlying glacial sediments along its present course, discharging into the wide, north-south-trending glacial trough that includes the Duwamish and Stuck river valleys near present-day Auburn and Pacific.

At least three more lahars deposited material in the White River drainage after the Osceola. This young geologic history and setting of the White River is the reason that the river has the largest sediment loads of any river in King County, and the sediment strongly influences the flooding and channel migration hazards.

As a result of the combined effects of glacial and postglacial alluvial processes, the White River has formed distinct reaches, from upstream to downstream: mountain valley headwaters, a canyon reach, and an alluvial fan that is progressively filling a low-gradient glacial valley. The mountain valley headwaters reach in King County includes the portion of the river upstream of Mud Mountain Dam and downstream of the dam for about 2 miles to where the river exits a bedrock-controlled gorge. The canyon reach extends downstream from the gorge outlet past the City of Enumclaw, which is elevated above the river on the Osceola plateau, and through a forested and undeveloped canyon that includes Muckleshoot

Tribe lands. The alluvial fan reach begins at the outlet of the canyon reach at about River Mile 8.2 and extends to the confluence with the Puyallup River. The river crosses the King-Pierce County boundary at about River Mile 5.55.

The White River alluvial fan underlies the cities of Auburn and Pacific, and fluvial processes active on the fan were the cause of a 1906 channel avulsion that resulted in the White River abandoning its channel flowing north to the Green River and shifting to the south to a confluence with the Puyallup River. River engineering led by the Inter-County River Improvement District and its successors built and maintained levees and a concrete wall, cleared woody debris from the river, and straightened and dredged the channel until 1987. The vertical adjustments of the White River channel following the 1906 avulsion have been strongly influenced by human river management.

A recent study of sediment flux trends along the White River determined that coarse sediment delivered to the lower White River in the alluvial fan reach is sourced from the Canyon Reach immediately upstream (King County 2019, Anderson and Jaeger 2019). A grade break in the river channel called a knickpoint that demarcates the transition between erosion upstream and deposition downstream is located at approximately River Mile 9.5 (and migrating upstream) within a low-gradient reach on the alluvial fan. As a result of the 1906 avulsion and subsequent channel dredging, the current White River channel remains shorter and steeper than the pre-avulsion channel. Sediment will continue to deposit on the alluvial fan as the river adjusts to the avulsion and 20th century river engineering disturbances.

A primary tributary to the White River, the Greenwater River basin is in the Cascade Range at the eastern edge of the Puget Lowland, with headwaters that drain slopes of volcanic bedrock associated with Mount Rainier. Bedrock exposures in the river valley bottom exert influence on fluvial processes at the basin scale and control channel migration in a few locations. Younger geologic formations that determine the sediment regime and that are relevant to flooding and channel migration in the Greenwater River include more erodible sedimentary deposits, such as lahar deposits including the Osceola mudflows, alpine glacial deposits, and landslide debris. The Greenwater River headwaters are in a forested, nonglaciated alpine basin.

Hydrology and Hydraulics

Most major White River floods occur between November and February. With headwaters on Mount Rainier glaciers, snowmelt also increases White River flows in late summer, but typically not to a level of flood concern. The primary determinant for flooding characteristics in the White River since 1948 is the presence and flow control operations of the Mud Mountain Dam project operated by the Corps (King County 2006).

As a sole-purpose flood protection facility near River Mile 29.0, Mud Mountain Dam reduces peak flood flows and releases the stored water at a lower flow over a longer duration than would occur if the dam were not in place. The dam is Congressionally authorized with a primary purpose of controlling floods along the lower Puyallup River in Pierce County; however, the Corps also operates the dam to achieve flood benefits on the White River whenever feasible (King County 2006). A diversion dam at the City of Buckley also diverts flow to Lake Tapps that is eventually returned to the river in Sumner. Since the cessation of the Lake Tapps hydropower project in 2004, flow diversions have not had a significant effect on flows on the White River. The diversion dam and associated fish trap were replaced in 2021 with the Mud Mountain Dam Fish Passage Facility, operated by the Corps in cooperation with Cascade Water Alliance, the operator of the adjacent Lake Tapps diversion structure.

The Corps revised the Mud Mountain Dam operations through an update to the Water Control Manual (WCM) in 2004. The significant change in operations was to limit discharges to 12,000 cfs when feasible for all events up to and including the 1 percent annual chance flood (Northwest Hydraulic Consultants 2008). The Corps again modified dam operations after flooding in January 2009. This flood event greatly affected the downstream communities of Pacific and Sumner due to high flows encountering diminished channel capacity from ongoing sedimentation in this portion of the river. Since 2009, various approved deviations from the 2004 WCM have been in effect to allow for dam operations to target lower outflows from Mud Mountain Dam, with the goal of reducing flood risks to the communities of Pacific and Auburn.

Flood hydrology below Mud Mountain Dam is expected to change as flood risk reduction projects along the lower White River are completed. The Corps revisits channel capacity below the dam over time and as flood mitigation projects are implemented. Levee setback projects completed and planned by King County and the City of Sumner are designed to increase channel capacity in the vicinity of Auburn, Pacific, and Sumner. These projects will mitigate downstream flooding such that the Corps can release larger peak flows from Mud Mountain Dam. Future peak flows are expected to more closely resemble the historic peaks from the years following dam construction. All present and future outflows from the dam are at the discretion of the Corps.

Table 2.5-1 lists the current flow quantiles developed for FEMA floodplain mapping of the White River. The flow quantiles are based on hydrologic data for the post-Mud Mountain dam period of record from 1946 to 2007. **Table 2.5-2** shows recent high flows from the White River above Boise Creek at the Buckley gage, and **Table 2.5-3** shows the highest flows recorded at the White River near the Buckley gage. The “White River near Buckley” gage operated from 1928 – 2003, at which point it was removed as part of a Tacoma Water pipeline replacement project. It was replaced with the “White River above Boise Creek at Buckley” gage in 2004, which continues to operate.

TABLE 2.5-1
FLOW QUANTILES FOR THE WHITE RIVER

Percent Chance Exceedance	Return Period	At Auburn (cfs)
10	10-year	14,000
2	50-year	15,300
1	100-year	15,500
0.2	500-year	19,000

TABLE 2.5-2
RECENT HIGH FLOWS AT THE WHITE RIVER ABOVE BOISE CREEK AT BUCKLEY GAGE (USGS 12099200)

Date	Flows
2022-03-01	6,630 cfs
2015-12-08	6,760 cfs
2012-02-23	7,290 cfs

TABLE 2.5-3
HIGHEST PEAK FLOWS RECORDED AT THE WHITE RIVER NEAR BUCKLEY GAGE (USGS 12098500) FOR THE PERIOD OF RECORD, 1928–2003

Date	Flows
1933-12 (specific date unknown)	28,000 cfs
1932-02-26	17,000 cfs
1932-11-13	16,500 cfs

Ecological Context and Salmonid Use

The White River and its tributaries provide spawning and rearing habitat for ESA-listed spring-run Chinook, winter-run steelhead, and bull trout. Non-listed species present in the watershed include coho, pink, chum, sockeye, rainbow, cutthroat, and whitefish. Pristine tributaries in Mount Rainier National Park provide most of the critical bull trout spawning/rearing habitat within the system (Marks et al. 2021). The White River spring Chinook population is the only remaining spring Chinook salmon stock in the south Puget Sound (WRIA 10 2018).

Above Mud Mountain Dam (River Mile 35.5), the river is largely unconfined by artificial structures, except where State Route 410 is adjacent to the river and at the mouth and lower section of the Greenwater River (King County 2006). Mud Mountain Dam (River Mile 29.6) is a complete barrier to upstream fish passage on the White River. Salmon are collected at the Mud Mountain Dam Fish Passage Facility, located near Buckley (River Mile 23.6), and trucked upstream (WRIA 10 2018). The 6 miles between Mud Mountain Dam and the fish passage facility are suitable habitat for salmonids, but there is only modest spawning in this reach because of lack of fish access (Marks et al. 2021).

Between the fish passage facility and River Mile 11, there are some areas of high-quality habitat, particularly on the Muckleshoot Reservation, where the channel has been allowed to migrate and damaged levees and revetments have not been repaired or replaced (King County 2006). Several large side channels and log jams in this reach provide valuable spawning and rearing habitat.

Below River Mile 11, the river is largely confined by levees and revetments, and there is substantially less habitat complexity and spawning gravel in this reach. Extensive removal of large wood and channelization in the lower river in the early to mid-1900s have greatly simplified habitat (King County 2006; WRIA 10 2018). Riparian buffers are limited along the lower White River, contributing to higher water temperatures.

Several tributaries to the White River are important for salmonids, including the Greenwater, Clearwater, and West Fork White rivers, as well as Boise and Huckleberry creeks. The West Fork White River, in particular, offers excellent salmonid habitat, while Huckleberry Creek—a tributary to the West Fork White River—consistently supports the highest densities of spring Chinook and coho spawning in its lowermost half mile.

Countyline floodplain reconnection project on the White River, November 2023

Identified limiting factors in the White River basin include a loss of floodplain and off-channel habitat, a lack of habitat-forming flow regimes, fish passage barriers, degraded riparian corridors and instream habitat complexity, and depleted large wood and prey resources (WRIA 10 2018; Kerwin 1999). Other limiting factors are identified as increased channelization and sediment loads, a loss of substrate stability, reduced spawning and rearing habitat, and impaired water quality (WRIA 10 2018). Several water bodies in the White River basin were included on the 303(d) list in 2018 for water quality impairments, including the White River (impaired for temperature, pH, and fecal coliform), Boise Creek (temperature, pH, and fecal coliform), and the Clearwater River (temperature).

Salmon recovery goals for the White River include removing levees and reconnecting floodplains, increasing riparian buffer function, and removing large physical barriers to fish movement and migration. Some of the strategies to meet these goals include protecting and restoring highly productive areas, reconnecting the floodplain along the mainstem river, removing barriers, restoring the hydrologic regime, and improving water quality (WRIA 10 2018).

King County projects on the middle and lower Boise Creek basins have improved spawning and rearing habitat conditions. Recent wood placement and floodplain reconnection projects on the Clearwater and Greenwater rivers completed by the South Puget Sound Salmon Enhancement Group have improved habitat and increased floodplain function. The King County Countyline Levee Setback project in the lower White River also provides a large area of reconnected floodplain that is used by juvenile salmonids and provides flood conveyance. Several future projects along the lower White River are being planned by the City of Sumner, King County, and Pierce County that will reconnect additional floodplain areas and improve habitat function and flood conveyance in the reach.

Primary Flood and Erosion Hazards and Risks

The Mud Mountain Dam project, located at River Mile 29.6 of the White River, is a single-purpose project providing congressionally authorized flood control focused on a control point on the lower Puyallup River in Pierce County (50,000 cfs at the USGS Puyallup River at Puyallup gage), with secondary flood control benefits to the lower White River Valley in King County.

Flood and channel migration hazards pose risks to rural residences in the Enumclaw area and to the communities of Auburn and Pacific along the lower White River in the alluvial fan reach. Along the White River, the primary flood protection infrastructure maintained by King County is a set of levees and revetments that were built through the 1914 Inter-County River Improvement Agreement. Channel migration hazards have the potential to impact roads, bridges, park amenities, utilities, residential property, and other infrastructure.

White River overbank flooding near Pacific, November 2021

In and around the cities of Auburn and Pacific, flood and channel migration risk along the lower White River, is being driven, in large part, by the natural accumulation of sediment. These cities are situated on a large-scale alluvial fan that receives sediment eroded from the steep channel bed and banks upstream. The decrease in channel slope at about River Mile 9.0 (where the White River flows out of the canyon reach and onto the lower gradient valley) induces sediment deposition. Where levees are present on both sides of the river, sediment is unable to be deposited across the floodplain, resulting in concentrated deposition within the river channel. Monitoring of the channel bed elevation since 1988 documents this sediment accumulation and shows a reduction in channel capacity, which is resulting in an increased risk of overbank flooding into the cities developed on the floodplain.

The Greenwater River, a tributary to the White River, has two revetments that deter channel migration, one of which protects a sole-access bridge to King County residences on the north side of the river. These structures are at risk of overbank flooding and channel migration during large flood events. Landslides and debris flows in the upper Greenwater River watershed can also increase flood risk by delivering large amounts of sediment to the channel, thereby reducing channel capacity to carry floodwater.

King County mapped landslides within river corridors, including the White and a portion of the Greenwater, in 2016. This work identified areas of potential deep-seated landslides that are in contact with the river and large enough to partially or completely block the river channel and affect flooding occurrence and severity (King County 2016). King County also identified locations of potential smaller landslides and debris flows, which can contribute large amounts of sediment that impact flooding locally and downstream as sediment is moved and stored within the river channel (King County 2016).

Other tributaries to the White River with flood risk concerns include Boise Creek and Red Creek. Most of Boise Creek is a low-gradient stream on the surface of the poorly drained Enumclaw plateau. Much of the channel of Boise Creek and its tributaries has been straightened and deepened to improve drainage in rural areas. Several rural residences are present on the portion of Red Creek that runs on the White River floodplain, and the flood risk includes inundation, channel migration, and access road flooding.

Flooding could worsen water quality issues through inundating contaminated areas, particularly areas with fecal coliform bacteria (thought to be caused at least partly by failing septic systems in Boise Creek; King County 2013) and pH impairment (due to excessive algal growth stemming from excess phosphorous from both wastewater treatment plants and nonpoint sources; Ecology 2022). Also, wood accumulations on the lower White River occur on riverbanks, gravel bars, and bridge piers and abutments, and can pose a risk to infrastructure and increase flood risk in the vicinity of bridges.

Potential Impacts from Climate Change and Other Future Changes

Analysis of projected changes in flood flows for the White River will be completed in 2024. In the interim, analysis completed for the Green River can provide some insights into what to expect for the White and Greenwater rivers.

By the 2080s, the 10-year and 100-year peak flow events for unregulated streamflow for the Green River near Auburn (USGS ID: 12113000) are projected to increase 19 percent (range of -8 to 75 percent) and 28 percent (range of -34 to +96 percent), respectively, under a high greenhouse gas emissions scenario, relative to the 1970–1999 average (Mauger and Won 2020). The degree to which Howard Hanson Dam can mitigate these projected changes is a current area of research. Preliminary analysis suggests relatively small changes in regulated peak flows in the Green River below the Howard Hanson Dam, assuming that future regulated flows are managed in the same way (Mauger and Won 2020). Expanded streamflow modeling to be conducted in 2024 will provide updated insights on projected changes in both regulated and unregulated flood flows for the Green River due to climate change, in addition to projected flows (regulated and unregulated) for the White River.

Higher winter streamflows and increases in flood flows are expected in the White River watershed as warmer winter temperatures drive a shift toward less snow and more rain at lower and mid-elevations.[5] Warmer winter temperatures also contribute to decreased water storage in snow and glaciers and increased glacial retreat on Mount Rainier. A 2023 study by the USGS found that glacial area around Mount Rainier declined 41.6 percent between 1896 and 2021 (Beason et al. 2023).

5 Higher elevations that remain below freezing in a changing climate may see higher snowpack in response to projected increases in winter precipitation. However, the total amount of snowpack will still decline given the smaller amount of surface area receiving snow.

Loss of glaciers is expected to contribute more sediment to rivers and streams. However, an evaluation of the effects of glacial retreat from climate change on sediment supply to the White River found that a change in sediment supply to the alluvial fan reach of the river near Auburn, Pacific, and Sumner should not be expected for a period of decades, even with substantial glacial retreat (Anderson and Jaeger 2019). This conclusion was based on a sediment flux analysis that showed that the majority of sediment sourced from Mount Rainier's glaciers is stored in the upper reaches of the river between the glacier's terminuses and the alluvial fan reach. As a result, the effect of glacial retreat on sediment supply in the White River—and the corresponding effect on flood risk—is uncertain.

Historically, high flows on the White River resulted in channel migration upstream of Auburn and the transport and deposition of sediment in the Pacific and Auburn reaches of the river. Consequently, the lower White River may experience an increase in sediment deposition and an accelerated loss of flood conveyance due to higher peak flows resulting from climate change. This is because higher flows can transport more sediment, of which there is an abundant supply upstream of Auburn and Pacific. The result could produce extreme consequences for communities along the lower White River as the active channel and areas of connected floodplain fill with sediment over several decades. Although raising levees can restore flood conveyance lost to sediment deposition, they can also "perch" the river above the floodplain and exacerbate shallow groundwater conditions that already impact urban flooding in portions of the City of Pacific.

Changes in high-flow frequency or duration caused by climate change may increase juvenile salmon access to off-channel floodplain habitats for rearing and refuge, although juvenile stranding could occur in response to reduced summer flows (Whitely Binder et al. 2019). Increasing summer water temperatures associated with climate change will negatively impact migrating adult and juvenile salmonids in the White River and its tributaries, as water temperatures in the lower watershed are already elevated due to insufficient riparian buffers in developed and agricultural areas. Increased water temperatures could influence behavior and migration of bull trout in particular, as bull trout require colder temperatures than many other salmonids in the White River. Under future climate change scenarios, thermal refugia provided by reconnected floodplain areas, riparian buffers, and diversity in habitat types (e.g., deep pools) will become even more important.

Ultimately, Mud Mountain Dam operations by the Corps will determine high flows that impact changes to both sediment transport and salmon.

Risk Assessment

A flood hazard risk assessment using Hazus evaluated the effects of riverine flooding on nearly 30,000 total structures in the King County portion of the White River watershed. This analysis revealed the following:

- In the watershed, 35 structures were found to be exposed to the 10 percent annual chance flood, 311 structures were found to be exposed to the 1 percent annual chance flood, and 352 structures were determined to be exposed to the 0.2 percent annual chance flood.

- Of the 351 critical facilities located in the watershed, two are exposed to the 10 percent annual chance flood, 18 are exposed to the 1 percent annual chance flood, and 20 are exposed to the 0.2 percent annual chance flood.
- The White River watershed has one repetitive loss structure, which is not exposed to the 10 percent annual chance flood but is exposed to the 1 percent and 0.2 percent annual chance floods.

With the numbers of structures identified as exposed to flooding, Hazus generated estimates of potential flood damages in the watershed. **Table 2.5-4** illustrates potential flood damages resulting from three return intervals.

TABLE 2.5-4
SUMMARY RESULTS FROM HAZUS ANALYSIS OF POTENTIAL RIVERINE FLOOD DAMAGES IN THE WHITE RIVER WATERSHED

Percent Chance Exceedance	Return Period	Potential Structure and Contents Damage – All Structures	Potential Structure and Contents Damage – Critical Facilities
10	10-year	$0	$0
1	100-year	$8,825,719	$1,093
0.2	500-year	$10,427,406	$1,093

2.6 Tributary, Coastal, and Urban Flooding

Overview

Flooding associated with King County's mainstem rivers, like the Cedar, Green, Snoqualmie, South Fork Skykomish, and White rivers, was the primary focus of King County's past flood plans. While natural riverine flooding and channel migration continue to present risks to county residents, property, and infrastructure, other sources of flooding also present risks. Although these are not new risks, management of these risks is becoming more challenging due to continued population growth and development, changing environmental conditions and regulations, and the potential effects of climate change. This Flood Plan is intended to represent the range of flooding and erosion hazards that pose risks across the county, so the scope of the 2024 Flood Plan includes tributary, urban, and coastal areas.

The following sections summarize, at a high level, flood or flood-related issues for tributary, coastal, and urban settings in King County. Since King County has not included these topics as deliberately in past flood planning, the planning process involved a series of workshops focused on each of these three flooding types. The workshops were structured to hear from city, tribal, special-purpose district, and nonprofit staff, as well as members of the public, about the nature of flooding caused by these sources, the impacts, and potential solutions. The information shared during these workshops directly informs the following discussion.

While each of the topics is treated separately, it is important to note that extensive overlap exists across these flooding types (for example, many coastal and tributary flood hazard areas are located within urban areas). The many linkages between these sources of flooding means that solutions must also recognize and address the overlap and be coordinated across county agencies and between King County and other local governments and partners.

Tributary Streams

Tributary streams comprise a vast drainage network that delivers water, sediment, wood, and other organic material to King County rivers, lakes, and Puget Sound. The natural function of tributary networks is vital to flood resilience, stormwater management, ecosystem health, and sustenance of threatened and endangered salmonids. The total number of named and unnamed tributary streams in cities and unincorporated King County is in the thousands.

Input on Tributary Flooding

Partners and community members frequently described tributary streams as causing flooding of private residential and agricultural properties, and indicated that tributary flooding is getting worse. Reasons identified as possible causes of worsened tributary flooding included changing precipitation patterns, increases in impervious surface areas that produce more stormwater runoff, runoff from historic development that was not subject to modern stormwater controls, and insufficient channel capacity to manage flows of water and sediment. Comments shared with King County indicate that these conditions are driving increases in flooding in areas that did not flood or flooded infrequently. Stormwater runoff that flows into tributaries in urban areas was cited as contributing to increased flooding and sediment deposition lower in those watersheds. Many community members and partners identified inundation of roads as a problem associated with tributary flooding, arising due to a combination of insufficient channel capacity, undersized culverts, armored shorelines, and piped stretches of streams that are unable to adequately convey flows. Beaver activity was also mentioned as contributing to private property and farmland flooding. Flooding associated with May Creek (a tributary to Lake Washington) was also raised as a concern.

Geology, Geomorphology, and Hydrology of King County Tributary Streams

As it is with the larger rivers in King County, the geology and geomorphology of tributary streams are dominated by processes that were active during and immediately following continental glaciation, when many sediments were deposited. Streams take several forms, depending on the topography, aspect, and size of the watershed areas they drain. Flooding characteristics are generally specific to each type of stream.

Following are brief descriptions of the types of streams present in King County and some examples of each type:

- **Post-glacial valley –** Similar to the Cedar and middle Green rivers, post-glacial valley streams are generally steep, incised into unconsolidated glacial sediments, and confined within narrow valleys with a limited-to-absent floodplain. The most downstream reaches of these streams at their confluence with a water body may contain a larger, more developed floodplain. (Examples: Coal, Willows, and Seidel creeks.)
- **Glacial valley –** These streams are situated in broad, flat valleys eroded by glaciers or glacial meltwater streams, not the modern streams themselves. These streams are now “underfit,” meaning they meander across only a portion of their floodplain. Riparian wetland complexes are common within the larger valley setting, which may have once been the site of a glacier-dammed lake. (Examples: Issaquah, Bear, Cottage, Evans, Soos, and Patterson creeks.

- **Alluvial fans –** While not a stream type, per se, alluvial fans occur with some frequency where streams discharge from a steep valley onto flatter ground (some rivers, such as the Tolt and Raging, also have alluvial fans). The term is used here to denote a feature associated with tributaries that was not identified in previous King County flood plans. An alluvial fan is a cone-shaped accumulation of sediment situated where a stream transitions from steep topography to the flatter floodplain of a larger river, a lakeshore, or the coast. The fan typically has multiple stream channels that were occupied by the stream at some point and could become active again in the future. Streams with an alluvial fan typically have a moderate-to-high sediment load and may be subject to debris flows. (Examples: Tokul, Griffin, Tuck, and Money creeks; unnamed streams along valley walls of the Green, Raging, Snoqualmie, Cedar, and Sammamish rivers.)
- **Non-alluvial –** A non-alluvial stream lacks a well-developed floodplain and tends to be steep and subject to debris flows and rapid flooding. Bedrock may be exposed in the stream or present in or near the subsurface. The stream type usually transitions to an alluvial fan at the downstream end. (Examples: Tokul, Griffin, Maloney, and Adair creeks, and many Cascade Mountain streams.)
- **Enumclaw Plateau –** Deposition of the Osceola mudflow, a coarse- to fine-grained volcanic deposit from an eruption on Mount Rainier's north side about 5,600 years ago, formed a broad plateau near Enumclaw. Flat topography and slow-draining soils characterize the Enumclaw Plateau, except for the White River and parts of Newaukum and Boise creeks, which have carved channels into the plateau through the surface of the mudflow deposits. Limited drainage within the Enumclaw Plateau resulted in a distinct natural stream pattern that was heavily modified into a network of straight, narrow, and deep stream channels and ditches constructed along road rights-of-way and property lines to provide agricultural drainage. Although this type of orthogonal drainage pattern is somewhat typical of areas modified to improve agricultural drainage, the slow-draining subsurface soils from the Osceola mudflow contribute to an exaggerated version of this pattern. **Figure 2.6-1** shows the plateau's engineered network of stream channels that flow straight and have right angle turns rather than the more gradual meanders of natural streams.

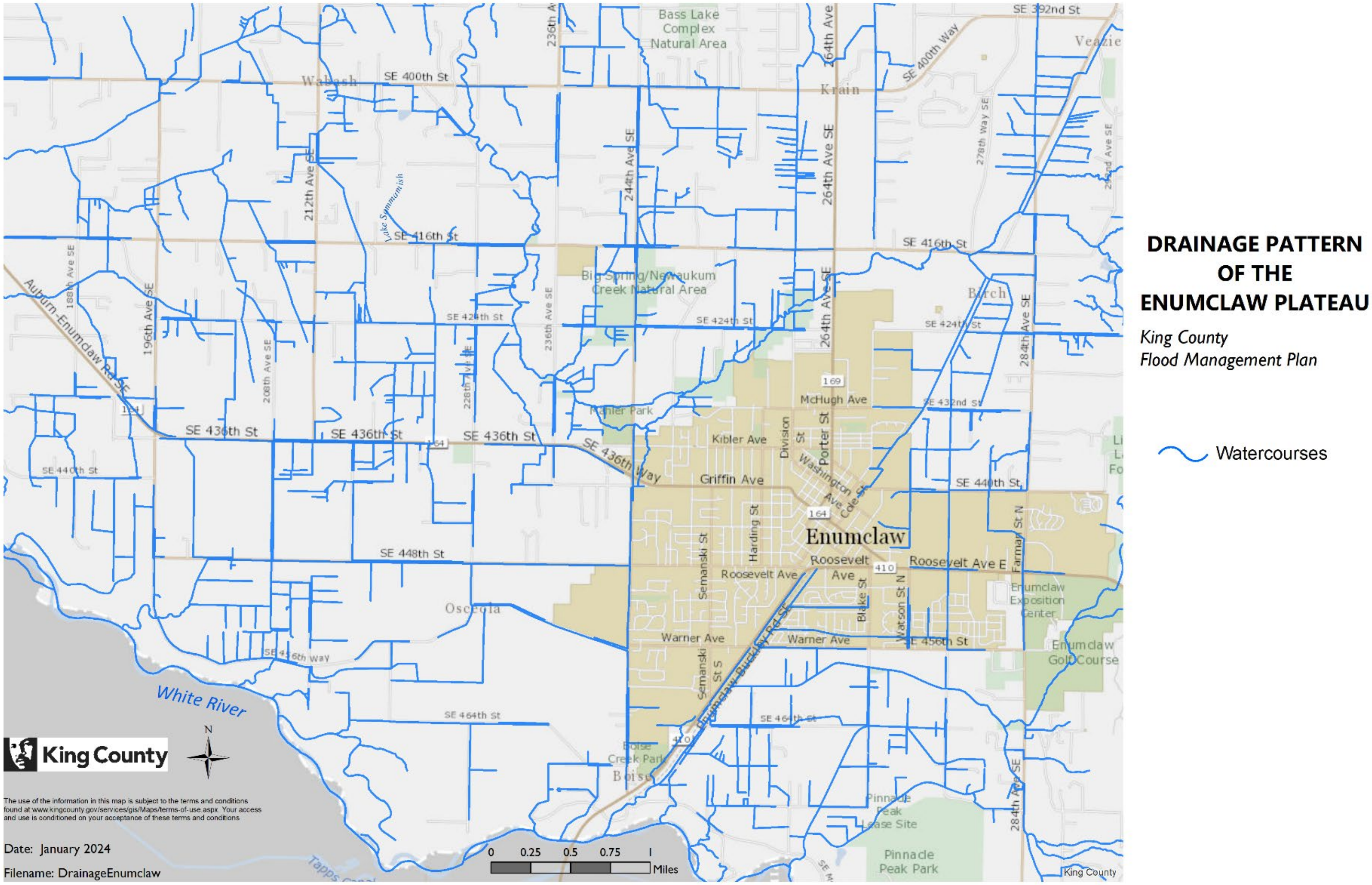


Figure 2.6-1
Drainage Pattern of the Enumclaw Plateau

Ecological Context of Tributary Streams

Tributaries provide spawning, foraging, rearing, and overwintering habitat for salmonids (Rice et al. 2008), including tributaries that are non-natal systems (King County 2019). Small streams and tributaries are also important year-round habitat for resident salmonids like trout. Tributary mouths are known for having high ecological diversity and being very productive for salmonids. Pools formed at tributary confluences can provide holding habitat for adult salmonids, and the area between tributaries and mainstems can also increase habitat diversity and complexity (Rice et al. 2008).

Tributaries offer refugia from high mainstem flows during floods. Some tributaries provide cool water inputs, provide cold water refugia from warmer mainstem rivers in summer, and increase mainstem productivity via nutrient input (Rice et al. 2008). Tributaries vary in habitat quality and seasonal availability, but even intermittent streams and severely altered tributaries (e.g., channelized streams) support salmonid use (Lucchetti et al. 2014). Tributary streams and their associated riparian forests also provide valuable habitat for terrestrial wildlife species in King County, including many species of birds, mammals, and amphibians.

Primary Flood and Erosion Hazards and Risks for Tributary Streams

King County's previous flood plans presented limited information on tributary flood hazards and risks, focusing only on tributary streams that have county-owned and -maintained flood risk reduction facilities (such as revetments and levees). These facilities are present along very few tributaries throughout the county, while tributary flood hazards are present in many more locations.

Typical tributary flooding includes flows exceeding stream banks, backwatering due to undersized culverts or narrow bridge abutments, and channel migration—including avulsion, bank erosion, or other forms. Tributary flooding occurs throughout the county in urban and in rural areas and is often characterized by fast flows that carry sediment and debris. This type of flooding can have erosive power that damages public and private property and infrastructure and adversely impacts a variety of land uses.

Tributary stream type largely determines the flooding characteristics in the vicinity of a given stream. As with rivers, tributary flooding and erosion are natural processes. Human-altered hydrology and infrastructure that was not designed or constructed to allow for natural process can exacerbate the natural tendencies of tributaries and increase flood risk. Alterations in hydrology include impervious surfaces; the construction of dams, levees, and culverts; stormwater systems that reroute runoff; water withdrawals; and the effects of climate change. Examples of infrastructure that affect tributary flood risk are undersized culverts that do not have the capacity to convey water and roadways that were built within a floodplain, impeding natural floodplain function.

Tributary under State Route 169 flooding from overwhelmed culvert, 2020

The flood hazards typical to each type of stream are as follows:

- **Post-glacial valley –** Since these streams are typically fairly steep, they carry moderate to high sediment loads and have somewhat flashy hydrology. Flooding causes these streams to carry debris, and the banks are subject to erosion and landslides. These processes cause these streams to widen as they develop floodplains. Bank erosion and channel migration can occur throughout the length of these streams, while flooding by inundation typically affects the lower stream reaches.
- **Glacial valley –** Underfit streams in broad, flat valleys tend to have very shallow gradients. These shallow gradients, combined with the fine-grained sediments that typically underlie glacial valleys, contribute to slow drainage. The streams are naturally highly sinuous and meandering. Flooding, combined with wetland environments and high groundwater tables, can extend from valley wall to valley wall. Channel migration rates are low in these streams, but local bank erosion is common, especially where the streams have been modified to improve drainage, at bridges and culverts, and on the outside of meander bends. These tributaries also may be subject to backwater flooding if they are blocked from discharging into a mainstem river or larger tributary during flooding. As a result, glacial valley stream types are highly susceptible to flooding associated with beaver dams.
- **Non-alluvial –** Similar to post glacial streams, non-alluvial streams have steep, often-straight channels with small drainage areas and minor tributary inputs. The upper reaches may have bedrock channels with low sediment loads. These streams do not have a well-

developed floodplain. Floodwaters are unable to spread out, making these streams subject to debris flows.

- **Alluvial fan –** Flooding at the alluvial fan portion of a stream can take several forms. As sediment on the fan accumulates, the active stream channel on an alluvial fan may abruptly change course (avulse) to form a new channel or re-occupy a former channel. Debris flows are another type of flood risk in an alluvial fan setting and can rapidly fill the channel with sediment and debris, causing the banks to overflow and possibly leading to a channel avulsion. The risk of debris flows can be increased by the presence of beaver-dammed ponds in headwater portions of streams with alluvial fans. Culverts and bridges are constrictions on alluvial fan streams that are especially susceptible to sediment deposition, and reduced conveyance capacity at these locations can cause flooding.
- **Enumclaw Plateau flooding –** The pattern of flooding from tributaries on the Enumclaw Plateau is overbank flow of the extensive network of drainage channels and backwatering into low areas and ditches. Stormwater runoff can overwhelm the capacity of these channels, and slow-draining soils prevent infiltration, which can contribute to flooding. Stream channels that have cut through the Osceola mudflow deposits (Newaukum Creek and lower Boise Creek) to the underlying glacial deposits have alluvial floodplains and are subject to bank erosion and channel migration.

Community and partner input shared about tributary flooding during development of the Flood Plan includes the following:

- Sediment transport and aggradation, including impacts from alluvial fans, contribute to flooding issues that damage private property and reduce stream conveyance capacity, which, in turn, contributes to evolving flooding problems. Past land use regulations did not effectively restrict development on alluvial fans and, as a result, occupied structures may be located on active fans.
- Overtopping or inundation of roads, including sole-access roads.
- Legacy drainage and stormwater management infrastructure that lacks capacity to handle current and projected flood volumes, including drainage infrastructure on private lands that is not maintained by local governments. Challenges with private drainage infrastructure in the rural areas of King County tend to be related to erosion downslope of drainage structure outfalls and associated with access-road crossings.
- The inability of tributary streams to discharge to their receiving bodies (a larger tributary, mainstem river, lake, etc.), causing backwater effects due to the inability of the stream to convey flow downstream. This is a relatively common occurrence, where a tributary is conveyed through a levee or a trail or road embankment via undersized infrastructure (pipe or culvert). Some examples of these phenomena can be found along the lower Green River, in the Snoqualmie Valley, or on the White River, among other locations.
- Many culverts installed decades ago were undersized or are not capable of handling current flow volumes during heavy or prolonged rainfall. The same is true for streams that were diverted into underground pipes many years ago—those systems often no longer function as well as originally intended. This may be a result of poor design (e.g., not fully understanding the channel capacity need at the time of construction), rerouting of stormwater in ways that overwhelms older systems, or an increase in nearby impervious

surfaces. Failure of older culverts due to rust and corrosion is also a problem. Several cities noted that they experience problems with undersized infrastructure along tributaries, including Lake Forest Park, Maple Valley, Newcastle, Sammamish, and Seattle.

- Beaver activity can cause long-term changes in flooding patterns. Beaver populations, which have been increasing in rural King County (King County 2022), build dams that back up water and can lead to flooding problems. At the same time, beaver dams store and slowly release water, support wetland and stream habitat functions, filter sediment and pollutants, and keep water cooler.

Coastal Flooding

Coastal flooding and erosion are natural processes, and the geologic instability of coastal bluffs, wave action, high tides, storm surge, ongoing sea level rise, inadequate stormwater controls, and clearing of vegetation on steep slopes all contribute to coastal flood hazards. In some areas of the county, urban runoff accumulation and high groundwater tables can exacerbate these coastal effects and, in turn, coastal flooding. Past development practices, such as the filling and channelization of the Duwamish River delta and other coastal estuaries, are also increasing risk under sea level rise and future climate conditions.

Input on Coastal Flooding

Coastal flood impacts described by community members and partners included impacts on commercial and industrial areas, waterfront residential properties, and low-lying areas farther inland, including on tidally influenced rivers. People often reported that coastal flooding is caused by multiple factors that can compound, including sea level rise, king tide events, storm surges, and heavy rainfall. Vulnerabilities include homes, businesses, access roads, sewer and on-site septic systems, and stormwater systems. Residents of Vashon-Maury Island raised concerns about flooding of the main connector road between the two islands, and community members from incorporated areas along the south county shoreline shared their observations of high water and erosion. Survey responses from those new to conversations about flooding identified coastal flooding as their greatest source of concern.

Partners shared that low-income communities and people who are not fluent in English have reported difficulties accessing support and translated information during coastal flood emergencies (such as the December 2022 flood event). Coastal property owners noted the challenges with retrofitting properties exposed to coastal flooding, in part due to environmental protections. Erosion and coastal bluff landslides are additional concerns related to coastal flooding and heavy precipitation, especially on Vashon-Maury Island. People shared concerns about the future impacts of sea level rise on infrastructure, especially in relation to the future resilience of coastal access roads and railroads, and an identified need was support for at-risk residents, including financial assistance for education and adaptation or relocation for property owners.

Geology, Geomorphology, and Hydrology of King County Coastal Areas

Marine waters of Puget Sound and large lakes, including Lake Sammamish and Lake Washington, occupy predominantly north-south-trending troughs formed during multiple glacial periods, the last of which is called the Vashon glacial period. The emergent extensions of these troughs form broad, low-gradient river valleys, including that occupied by the Duwamish River and its estuary at the southern end of Elliott Bay in Seattle.

Coastal uplands within King County are mostly underlain by layers of unconsolidated glacial sediments deposited during the last advance of the Puget Lobe ice sheet. Although local variability within these sediment layers exists, a generalized sequence of these sediments is as follows, with the youngest at the top of coastal bluffs and the oldest located progressively downslope: recessional sand, glacial till, advance outwash sand deposits, and fine-grained silt and clay underlain by older, non-glacial and glacial sedimentary units. These sediment layers are exposed and visible on the face of coastal bluffs. The till, fine-grained silt and clay, and older glacial units are more resistant to erosion than the sand. The relative impermeability of these layers causes instability and erosion above the layers, which is independent from erosion caused by wave action, tides, and storm surge. These sand deposits, along with sediment delivered to lakes and Puget Sound by rivers, are a primary source of sediment for Puget Sound beaches.

The natural geomorphic process of sediment delivery from bluffs to beaches has been disrupted by shoreline armoring, which includes bulkheads, sea walls, and riprap rock armor. The movement of sediment along beaches has also been disrupted by docks, jetties, and groins, depriving downdrift beaches of natural sediment replenishment and reducing beach ecological function and response to wave energy.

Ecological Context of Coastal Areas

Central Puget Sound is heavily urbanized, and shorelines and intertidal areas, including estuaries in King County, are degraded, altered, or lost due to dredging or filling, waste and wastewater disposal, nonpoint source pollution, shoreline armoring and development, sediment contamination, and the introduction of non-native species (Williams et al. 2001). The 103 miles of marine shorelines in King County are heavily armored with sea walls and bulkheads (King County 2020). In total, 64 percent of the county's shoreline is armored; the urban shoreline of the county is 84 percent armored, and the Vashon/Maury Island shoreline is 49 percent armored (King County 2019a). Most of the shoreline is composed of residential development, with commercial/industrial uses within Elliott Bay and the BNSF railroad along the northern shoreline making up the next largest land uses (King County 2005).

Many habitat types within the nearshore environment provide important habitat functions, including eelgrass meadows, kelp forests, tideflats, marshes, pocket estuaries, sand spits, beaches, bluffs, and marine riparian zones (Williams et al. 2001). Nearshore ecosystems support a broad variety of biological resources, including salmonids, forage fish, ground fish, rockfish, numerous invertebrates and shellfish, marine mammals, birds, and other wildlife (Williams et al. 2001).

The ecological functions provided by the marine shorelines and nearshore habitats of Puget Sound are critical for many species of fish and shellfish. These include spawning habitat for forage fish (some of which spawn directly on upper beaches), wave and current energy buffering, nutrient cycling, prey production, bird/wildlife habitat, water quality improvement, salmonid rearing, sediment sources for beaches, and bank stability and shade (riparian zones) (Williams et al. 2001, King County 2019b). Estuaries also provide a vital function for returning adult salmonids to acclimate from saltwater to freshwater environments as they migrate to their natal streams to spawn, and estuaries are important nursery areas for juvenile salmonids as they transition from their home streams to saltwater.

Primary Flood and Erosion Hazards and Risks

Many of King County's marine shorelines have houses or development located at the tops of bluffs (which face risks of landslide/erosion), on fill within the historic upper beach, or built extremely close to the shore. In the two latter cases, steep slopes are often present behind the shoreline development, meaning these structures face multiple risks. In many locations, septic systems are subject to flooding and shoreline erosion.

Dockton Park Marina king tide flooding on Maury Island, December 2022

Coastal flood hazards with the potential to impact the sheltered waters of King County include inundation, wave-generated shoreline erosion, and landslides. Coastal flooding often happens during "king tides," which refer to the highest predicted astronomical tides of the year, typically occurring from November through February.[6] King tides alone do not typically cause significant flooding, but when combined with wind-generated waves or storm surges caused by low-pressure systems, flooding of coastal areas can occur. This is especially problematic for areas that have significant fetch, like the north end of Vashon Island, the north end of Three Tree Point, or areas with lower-lying shorelines, like the Portage area on Vashon or the Lowman Beach area of West Seattle. During a storm surge, water levels and waves may run significantly higher than the predicted tide level, and these higher waters may result in flooding and erosion.

Shoreline erosion, landslides, and flooding along beaches at the base of coastal bluffs are related hazards. Natural hillslope instability within coastal bluff sediments is driven by routine weathering, wave action that erodes the toe of the bluff, and the combined effects of stormwater movement across the bluff face and groundwater movement within the sediments. Bluff erosion can steepen slopes and reduce the buttressing at the base of the bluff, thereby destabilizing the slope and depositing sediment on the beach. Natural wave action moves the deposited sediment along the shoreline, and seasonal variations in wind and wave energy reconfigure beaches on annual cycles.

Insufficiently managed stormwater is frequently a contributing factor to coastal landslides. Unlike in many other areas, stormwater should not be infiltrated into the ground near steep slopes and should instead be tightlined down to the beach to avoid increasing slope instability. Increased pore-water pressure at the interface of certain sediment layers forces horizontal movement of groundwater. The top of the silt and clay layer above this interface becomes a slip surface, which commonly is the cause of landslides on Puget Sound's coastal bluffs. While armoring of King County's shorelines can in some cases decrease the rate of coastal bluff erosion and landslides, it contributes to beach erosion, which, in turn, undermines typical shoreline protection structures and increases flooding by inundation.

King County has mapped a coastal high-hazard area that identifies homes and other development that face coastal flooding risk. During the flood planning process, community members and partners highlighted specific problem areas, including the Duwamish River, Vashon Island, and along the shoreline from West Seattle to Des Moines. Commonly observed flood issues include:

- Flooding during king tide and high tide events, especially near tidally influenced areas of rivers and streams.
- Overtopping of roads that access beach properties, with occasional flood impacts on the waterfront properties/structures themselves.

[6] Associated with a full moon where the moon, the earth, and sun are aligned in a straight line.

- Overwhelmed sewer and stormwater systems in many urbanized areas, especially within the lower Duwamish River's South Park and Georgetown neighborhoods.

Concerns about future flood issues include:

- Impacts from sea level rise (see *Climate Change* section below for more information on sea level rise).
- Flood impacts in the South of Downtown (SODO) neighborhood of Seattle.
- Worsening flood impacts on the built environment along the lower Duwamish River and the Vashon-Maury Island shoreline.
- Road flooding that overtops both roads that connect Vashon Island with Maury Island, including potential isolation of Maury Island due to coastal flooding that is expected to increase with sea level rise.
- Flooding of septic systems and wells.
- Clusters of housing and older neighborhoods that were built on the upper beach that are also backed by steep slopes, which greatly limit options to improve resilience in these locations.
- Compounded hazards, like flooding and landslides, can be difficult to assess. For example, winter storms can cause flooding and increase the likelihood of landslides through saturated steep slopes. Many houses that are at risk of coastal flooding may also face landslide risk.

King County received questions about the timeline for sea level rise impacts on coastal properties and whether large areas will flood that were previously unaffected or if the severity of flooding would mostly increase in areas that are already at risk. To address questions like this, the county is working on a project to model sea level rise and coastal flooding impacts using the USGS's Coastal Storm Modeling System (CoSMoS). The results of the modeling effort should be available in 2024 and will inform future decision-making about addressing various coastal flooding hazards. Community members and partners identified a need for ongoing modeling and studies to better understand coastal flooding and compound impacts.

In addition to coastal flooding and coastal erosion hazards, active faults in the Puget Lowland can generate tsunamis within Puget Sound waters and can cause coastal flooding in very unexpected ways. Although Puget Sound tsunamis are rare events, the time between the occurrence of a tsunamigenic earthquake in the Puget Sound region and the arrival of a wave will be very short—likely too short to warn residents—and their occurrence likely will be completely unexpected by the general public.

Urban Flooding

King County has extensive urban areas, most of which, but not all, are located within the county's 39 incorporated municipalities. Several urban areas are also located within unincorporated King County, including the communities of East Federal Way, North Highline, West Hill, Fairwood, East Renton, Skyway, and South Park (most of which is in the

City of Seattle). Many of these urban areas experience urban flooding, which includes flooding and flood-related erosion that is not always caused by overbank flow from King County's rivers and tributary streams. This may include flooding caused by stormwater runoff, high groundwater tables, ponding following intense rainfall, and overwhelmed urban storm sewer systems.

Input on Urban Flooding

Community members and numerous government partners raised concerns about increased stormwater flooding. Common observations about urban flooding problems related to increased development, inadequate capacity of stormwater management infrastructure, a lack of permeability in built environments, climate change, and urban areas located in the floodplains of major rivers, tributaries, and coastal areas. Community members and partners noted that heavy precipitation is exceeding the capacity of urban stormwater management infrastructure with increasing frequency because of climate change. Sediment loads from stormwater runoff are reducing conveyance capacity for urban streams and stormwater infrastructure, often exacerbating urban flooding issues and requiring increased maintenance. Partners noted that high water levels in receiving water bodies, especially in low-lying urban areas near rivers, lakes, and Puget Sound, are leading to decreased effectiveness of gravity drainage systems and pump stations. Beaver activity and sediment accumulation in stormwater systems and streams were also discussed as exacerbating issues in some cities. Commonly reported impacts from urban flooding included inundation of roads and other transportation infrastructure.

Geology, Geomorphology, and Hydrology of Urban Areas

Urban areas are typically developed on relatively flat or gently sloping surfaces. These low-relief surfaces within the glacially formed landscape of western King County include the following, with example areas in parentheses:

- Glacial upland areas typically underlain by sandy glacial outwash or dense, low-permeability glacial till (north Seattle, Capitol Hill, Federal Way).
- Floodplains underlain by sand and gravel alluvium (such as Redmond) with low-permeability silt/clay glacial lake deposits beneath the alluvium in many areas (Renton).
- Artificially filled areas, including former wetlands and bogs (Totem Lake in Kirkland, many areas in north Seattle), estuaries (South Park), and ravines (local residential areas).

The contrasting hydraulic permeability and porosity of subsurface soil and geologic units affect rain and stormwater infiltration rates, groundwater table elevation, and subsurface flow. As urban development becomes more dense, subsurface materials that previously infiltrated rain and stormwater can become overwhelmed, causing flooding. Familiarity with subsurface geologic conditions is important to understanding the causes of urban flooding.

Cedar River Flooding at Renton Airport, 1996

Alluvial valleys are groundwater discharge zones, meaning that the rainwater that falls on upland areas and infiltrates into the ground flows through the subsurface to eventually discharge to streams and rivers in the valley bottom. Intense urban development with a high percentage of impervious surface on the valley floor, such as the Kent and Tukwila portions of the lower Green River Valley, can affect groundwater movement.

Peak-flow hydrology has changed because of increased urban development. Small drainage areas common in urban settings are typically flashy, which results in higher, shorter duration floods than prior to urban development. Although current stormwater management standards aim to mitigate the impacts of stormwater runoff from development, the legacy of past development continues to impact urban hydrology.

Research has documented the effects of urbanization on small streams as well as larger rivers within urban areas (e.g., the Cedar and Green rivers) caused by hydrologic and hydraulic changes (Booth 1990; Cluer and Thorne 2013). Increased flow volumes and velocities first cause channel incision, deepening the stream and eroding and exporting sediment and wood from the system. Banks are undercut by the incision, leading to bank failure and further sediment and wood mobilization and export. As banks fail, the incised channel widens and tends to form an inset floodplain at a lower elevation than the pre-urbanization floodplain. Collectively, these have reduced the geomorphic function and degraded the ecological function of streams draining urbanized watersheds. Efforts to partially restore the original hydrology and geomorphic function of these streams may seek to add large wood, set back banks, and induce sediment deposition to reconnect the stream with the pre-urbanized floodplain.

Ecological Context for Urban Areas

Urban areas often are areas with habitat degradation/loss. In King County, many urban areas overlap with areas that were historically floodplain or estuary that have been filled and developed. Streams in urban areas tend to have highly altered hydrology and habitats. These streams tend to have lower overall salmonid productivity, and many have water quality issues related to pollutants entering the stream system through stormwater inputs.

However, parks, open spaces, gardens/backyards, airports, streams, and stormwater facilities in urban areas can provide habitat for fish/wildlife—particularly species adapted to living alongside humans. Even severely impacted habitats can be used (e.g., salmonids are observed in highly channelized streams and stormwater infrastructure). Urban areas also serve as migratory corridors for salmonids, birds, mammals, and amphibians.

Primary Flood and Erosion Hazards and Risks in Urban Areas

Flood and erosion hazards in urban areas are not new. Some urban flooding is a result of inadequate and undersized stormwater infrastructure and legacy effects, such as rerouting of runoff from one drainage basin into a different drainage basin. Surfaces such as pavement, pipes, and concrete-lined ditches deliver high-velocity flow to receiving streams with erosive force, causing excessive erosion of sediment, which is then transported downstream and deposited in urban areas.

Intensely developed areas with high percentages of impervious surfaces can experience ponding, seepage through pavement and foundations, and flooding due to upward pressure from a rising groundwater table. This issue may be especially acute near streams and rivers where the groundwater would naturally discharge, but when the river is in flood stage and the ground is saturated (e.g., Tukwila and Kent), the system may be unable to accommodate the rising groundwater. In the lower White River, shallow groundwater conditions are exacerbated by increased sediment deposition within the river channel and a subsequent rise in river levels, posing a flood risk to adjacent communities. At the same time, overbank flow onto the White River floodplain is an important source of groundwater recharge that supports streamflow in summer and early fall.

City of North Bend commercial area and street flooding, November 2006

Community members and partners engaged during the flood planning process identified several common urban flooding issues:

- Tributaries in urban areas overtopping their banks, especially due to high volumes of stormwater runoff.
- Large sediment loads overwhelming small streams and stormwater infrastructure.
- Flooding and backups due to inadequate capacity of stormwater infrastructure, combined sewer overflows, and culverts.
- Lack of natural drainage or floodwater storage capacity in urban areas.
- Inundation of roads and related transportation infrastructure, threatening driver and pedestrian safety.
- Intense rainfall resulting in flashy, rapidly rising water levels due to a lack of flow control, which, in turn, causes bank erosion and bank instability that can threaten properties and structures.
- Urban lakes with controlled outlets experience issues ranging from beavers damming their outlets to uncontrolled runoff inflows, which can cause flooding that affects homes and businesses.

- Undersized stormwater pipe systems, aging and failing pipes, and antiquated conveyance pipes that discharge to open channels create problems throughout urban areas in King County.
- Pump stations are often used in urban areas to reduce flood risks, even during minor flood events. Power outages at these facilities during storms can cause flooding.

Potential future flood problems identified include:

- Flooding in areas that have historically not flooded, including highly developed inland areas with significant impervious surface.
- Worsening flood impacts on private property and related economic impacts.
- Reduced effectiveness of pumping systems and increased inundation of low-lying areas due to sea level rise.

Convective storms are a mechanism contributing to flooding within small basins that may increase in the future because of climate change (see the following section for more detail). While spring and summer convective storms are rare in the Puget Sound region, these storms—which can involve heavy rainfall, thunder, lightning, and/or hail—are often spatially small, intense, and quick moving. The intensity of rainfall associated with convective storms can overwhelm urban stormwater systems and smaller streams and result in flash flooding and localized flooding in small basins. Areas recently burned by wildfires and denuded of vegetation are also susceptible to high-intensity rainfall from convective storms, leading to flooding and debris flows.

Potential Impacts from Climate Change and Other Future Changes

Effects of Climate Change on Tributary Streams & Urban Flood Hazards

Climate change is projected to enhance existing seasonal precipitation patterns in the Puget Sound region, leading to wetter winters and drier summers. While individual model results will vary, climate modeling predicts more winter rain overall and more winter precipitation falling as rain rather than snow in upper watersheds. The Puget Sound lowlands and lower-elevation mixed rain-and-snow watersheds are particularly sensitive to these changes, given the relatively warm winter temperatures already seen in these basins. Heavy rain events (e.g., atmospheric river events) are also expected to become more intense and more frequent. These changes collectively point to an increase in the volume of winter runoff into tributary systems and an increase in urban flooding in locations where stormwater control facilities are absent or unable to keep up with runoff volumes.

More research is needed on current trends and possible future changes in the frequency, intensity, and location of convective storms in King County and Western Washington. Climate scenarios project a decrease in summer precipitation; however, warmer land temperatures could create conditions more favorable for summer thunderstorms. On the other hand, a warming climate may make the atmosphere more stable and thus reduce the chance of thunderstorms. Climate models have difficulty capturing these storms due to their small size, making it difficult to assess changes in these systems.

Similar challenges exist for projecting changes in the location and intensity of rainfall in wintertime convective storms associated with the Puget Sound Convergence Zone (PSCZ). The PSCZ is a common weather phenomenon in which storms coming in from the Pacific Ocean are split by the Olympic Mountains and then reconverge in the Puget Sound area. This can bring bands of intense localized rainfall, typically over northern King County and southern Snohomish County. The PSCZ is more likely to occur in fall and winter. Because the PSCZ is driven by large-scale atmospheric circulations, models may be able to better capture changes in the PSCZ. However, these effects have not yet been studied.

Despite the uncertainty that currently exists regarding projected changes in convective storms, these storms could be a potential driver of flooding in small basins in King County and warrant further investigation. Stormwater management efforts to account for more intense winter precipitation, including more intense rainfall associated with atmospheric river events, should help address the potential for convective flooding in all seasons.

Changes in summer conditions will also impact tributaries. Lower snowpack, earlier spring snowmelt, and warmer and drier summer conditions extend and exacerbate summer drought conditions and low-flow impacts. These include warmer stream temperatures, disconnected streams, less available habitat for juvenile salmon, and direct mortality of salmonids. For example, lower summer streamflows may reduce available spawning habitat for early Chinook spawners and lead to dewatering of steelhead redds. Warmer stream temperatures can also decrease growth rates or kill juvenile salmon outright, slow or block adult salmon migration, and reduce adult salmon productivity.

The increased potential for wildfire in Western Washington may impact tributary streams and stream flooding post-fire, depending on fire location and intensity. Wildfires can increase the potential for landslides, erosion, flash floods, sediment loading, and debris flows in rivers, lakes, and streams due to the loss of vegetation and root structures that would normally hold soils in place. This risk is most acute within the 3 years following a fire. In more severe fires, the intense heat can also form a surface layer of hydrophobic soils (those that tend to repel water) that can dramatically increase runoff rates as infiltration is reduced. This can lead to flooding in the lowlands during even moderate storm events as runoff is concentrated in tributary stream channels.

Effects of Climate Change on Coastal Flood Hazards

Global sea level has risen on average eight to nine inches since 1880 and the rate of rise is accelerating (Lindsey 2022). Many factors contribute to how much sea level rises globally (absolute sea level rise) and at a given location (relative sea level rise). Major factors at the global scale include thermal expansion of the ocean and snowmelt contributions from land-based snow and ice, particularly from Greenland and Antarctica. The relative contribution of these water sources changes over time, with contributions from land-based snow and ice becoming the dominant contributing source later in the century (Miller et al. 2018, Appendix B; NRC 2012).

Locally, changes in vertical land elevation are a major factor affecting sea level rise at a specific location. One key contributor to changes in vertical land elevation is plate tectonics. The movement of tectonic plates can cause uplift or subsidence of the land surface over time that can offset (in the case of uplift) or exacerbate (in the case of subsidence) sea level rise at a given location. Other local factors that can contribute to changes in land elevation are soil compaction in areas built on fill or with heavy groundwater extraction, human activities that reduce the transport of sediment to floodplains and estuaries (such as constructing dams and levees), and geologic rebound from the last ice age (a process known as "glacial isostatic adjustment").

Sea level has risen more than 10 inches in Seattle since 1899 (as measured at NOAA's tide gage at Coleman Dock) and will likely rise approximately 1 to 2 feet by mid-century and 2 to 3 feet by 2100, relative to 2000, under a high greenhouse gas scenario (Miller et al. 2018). Lower and higher amounts of sea level rise are possible, with up to 5 feet of sea level rise considered a plausible upper estimate for 2100 based on current scenarios. Inundation of low-lying areas is expected along the Puget Sound shoreline due to sea level rise and increased tidal reach. This will expose more shoreline areas to periodic or permanent flooding, wave action, erosion, and damage from saltwater corrosion. See the examples presented in **Figure 2.6-2** (showing the Fauntleroy, Vashon-Maury Island, and South Park Areas), and **Figure 2.6-3** and **Figure 2.6-4**.

The potential for coastal squeeze also increases with sea level rise. In undeveloped nearshore systems, beaches and coastal marsh shorelines will migrate inland as sea level rises. However, in heavily armored areas, beaches and coastal marshes tend to be restricted by infrastructure. In these cases, rising sea level will degrade and permanently inundate beach habitats along the shoreline, eventually causing the habitats to disappear or become nonfunctional, as shown in Figure 2.6-4 (Krueger et al. 2009).

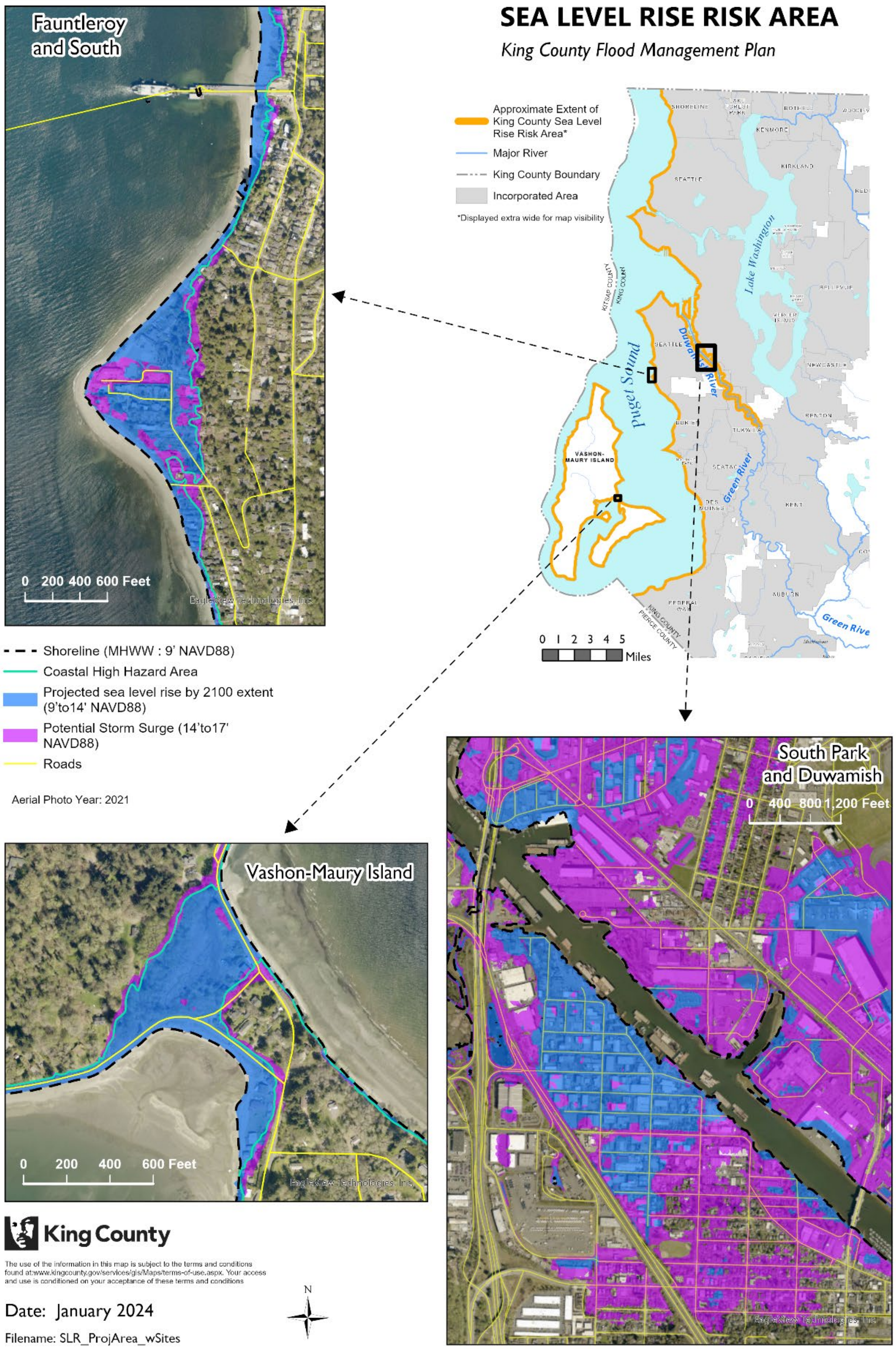


Figure 2.6-2
Sea Level Rise Risk Area

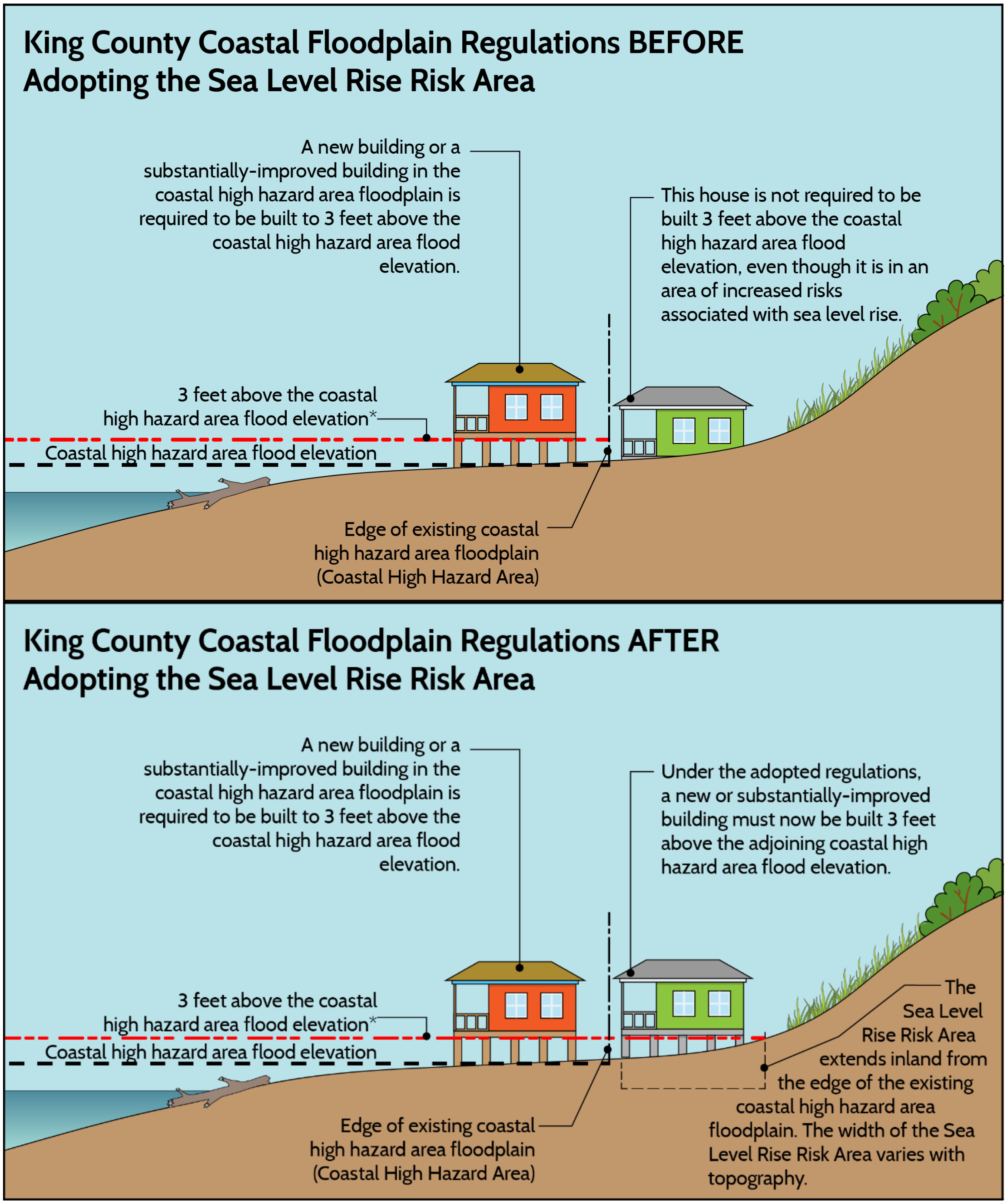


Figure 2.6-3
Comparison of Regulations (Before and After), Sea Level Rise Risk Area
This figure illustrates the boundary and associated building elevation requirements of the King County Sea Level Rise Risk Area, which applies only to Vashon-Maury Island. Additional provisions related to bluff setbacks and groundwater wells are not shown here.

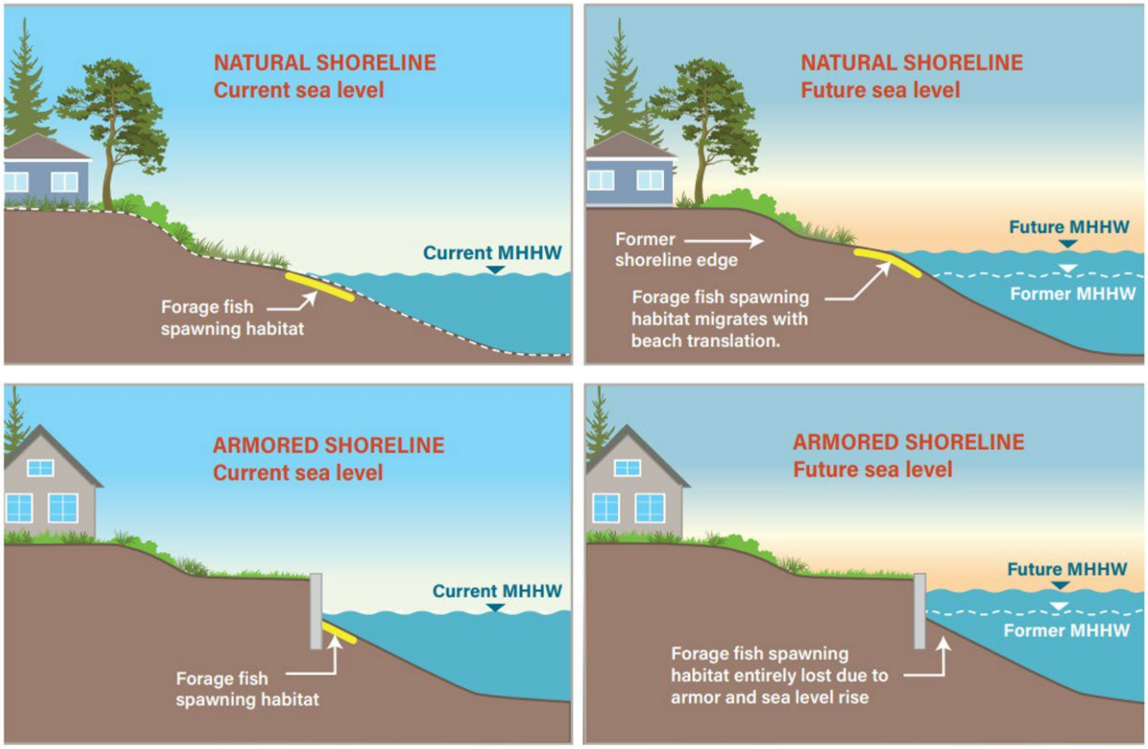


Figure 2.6-4
Coastal Squeeze in the Puget Sound Nearshore
Graphic illustrates the shallow areas where forage fish spawn and are being squeezed out of existence by shoreline armoring and sea level rise (Coastal Geologic Services).

Other potential impacts of sea level rise include a greater potential for erosion and landslides and exacerbation of freshwater flooding in the lower Duwamish watershed. Storm surge and storm-related wave events can overtop existing bulkheads and cause erosion of the shoreline, increasing the potential for slides. The projected increases in winter precipitation and heavy rain events noted above can further destabilize nearshore slopes. While these processes bring added risks to nearshore structures, sediment inputs from erosion, particularly from feeder bluffs, are critical to adapting the nearshore to rising seas and can be beneficial to maintaining salmon habitat in the nearshore environment.[7]

Finally, sea level rise can slow drainage of floodwaters, extending the duration of flooding or contributing to more widespread flooding. As noted above, more information on sea level rise and coastal flooding impacts in King County will be available in summer 2024 with completion of the USGS's CoSMoS model.

7 Feeder bluffs are coastal bluffs that deliver sand and gravel to nearby beaches as a result of erosion. The amount of sediment delivered, and how quickly it is delivered, will depend on a variety of factors. For more on feeder bluffs, see Ecology (2023).

Risk Assessment

King County's Hazus assessment evaluated the exposure of structures and critical facilities to coastal flood vulnerability (see Section 2.7 for more detail). This was possible with use of King County's delineation of a coastal high-hazard area, which is reflected on effective flood insurance rate maps and is used for regulatory purposes. The scope of the analysis was countywide and included all unincorporated and incorporated areas in the watershed-based results presented in the previous sections. However, the analysis did not isolate the potential vulnerability to tributary and urban flooding due to the complexity involved in that analysis.

The analysis used best available information, which included all flood modeling available through King County or the FEMA map service center, meaning that the vulnerability results may include data beyond what is reflected in effective Digital Flood Insurance Rate Maps. This section describes coastal flood vulnerability results, aggregates tributary and urban flooding, and presents available information.

Coastal Flooding

Hazus is a tool to estimate potential losses from flooding, but it is not without limitations. Namely, the model relies on available information, is an approximation, and does not account for the unique nature of each flood event. In the case of estimating the potential impacts associated with coastal flooding, the model used the existing coastal high-hazard area and did not incorporate data on potential sea level rise scenarios.

Neither the South Fork Skykomish/Snoqualmie or White River watersheds have any coastal flood exposure. **Table 2.6-1** presents exposure as identified for the Lake Washington/Cedar/Sammamish and Green/Duwamish watersheds. Of note, there is no critical facility exposure to coastal flooding in the Lake Washington/Cedar/Sammamish watershed.

Potential coastal flood damages were also assessed using Hazus, and those results are presented in **Table 2.6-2**.

Table 2.6-1
Exposure to Coastal Flooding

Flood Event	WRIA	Number Exposed (General Building Stock)	Total Structure Value Exposed (General Building Stock)	Total Content Value Exposed (General Building Stock)	Number Exposed (Critical Facilities)	Total Structure Value Exposed (General Building Stock)	Total Content Value Exposed (General Building Stock)
10% Annual Chance Coastal Flood	Lake WA/Cedar/Sammamish	N/A	N/A	N/A	N/A	N/A	N/A
	Green/Duwamish	5	$4,509,914	$3,232,414	N/A	N/A	N/A
2% Annual Chance Coastal Flood	Lake WA/Cedar/Sammamish	N/A	N/A	N/A	N/A	N/A	N/A
	Green/Duwamish	5	$4,509,914	$3,232,414	N/A	N/A	N/A
1% Annual Chance Coastal Flood	Lake WA/Cedar/Sammamish	42	$19,791,028	$12,997,828	N/A	N/A	N/A
	Green/Duwamish	818	$685,929,108	$486,575,075	26	$25,661,291	$33,213,049
0.2% Annual Chance Coastal	Lake WA/Cedar/Sammamish	42	$19,791,028	$12,997,828	N/A	N/A	N/A
	Green/Duwamish	1,119	$910,555,296	$640,100,699	27	$26,863,436	$35,016,266

Table 2.6-2
Potential Damages from Coastal Flooding

Flood Event	WRIA	Total Structure Value Damages (General Building Stock)	Total Content Value Damages (General Building Stock)	Total Structure Value Damages (Critical Facilities)	Total Content Value Damages (Critical Facilities)
10% Annual Chance Coastal Flood	Lake WA/Cedar/Sammamish	N/A	N/A	N/A	N/A
	Green/Duwamish	$111,530	$376,163	N/A	N/A
2% Annual Chance Coastal Flood	Lake WA/Cedar/Sammamish	N/A	N/A	N/A	N/A
	Green/Duwamish	$112,397	$378,858	N/A	N/A
1% Annual Chance Coastal Flood	Lake WA/Cedar/Sammamish	$4,636,598	$3,524,225	N/A	N/A
	Green/Duwamish	$45,955,081	$59,544,610	$249,306	$247,803
0.2% Annual Chance Coastal Flood	Lake WA/Cedar/Sammamish	$4,677,758	$3,526,367	N/A	N/A
	Green/Duwamish	$53,937,525	$63,116,587	$89,456	$247,803

Urban and Tributary Flooding

As noted in the introduction, urban and tributary flood hazards were not analyzed separately in the Hazus analysis. Viewing the results of the analysis for the incorporated areas of King County provides a glimpse into the extent of flood vulnerability in urban areas, yet the degree to which the vulnerability is related to tributary sources or other urban sources (i.e., stormwater runoff) is unclear. Identifying flood vulnerability arising from specific sources is an area for future investigation. Nonetheless, the results that follow (**Table 2.6-3**) provide insights into the extent of flood exposure present in different jurisdictions and the potential damages that could occur for given flood events. As with all other exposure and potential damage estimates provided in this Flood Plan, the data represent an approximation of potential damages and do not consider all scenarios or possible outcomes.

TABLE 2.6-3
POTENTIAL FLOOD DAMAGES TO GENERAL BUILDING STOCK AND CRITICAL FACILITIES FROM A 1 PERCENT ANNUAL CHANCE FLOOD EVENT, BY JURISDICTION (NON-COASTAL)

	Total Estimated Damages to General Building Stock (Structure and Contents)	Total Estimated Damages to Critical Facilities (Structure and Contents)	Total Estimated Damages
Cities			
Algona	$-	$-	$-
Auburn	$3,730,086	$-	$3,730,086
Beaux Arts	$-	$-	$-
Bellevue	$781,729	$251	$781,980
Black Diamond	$-	$-	$-
Bothell	$-	$1,049,761	$1,049,761
Burien	$1,012,392	$239,199	$1,251,591
Carnation	$1,421,369	$-	$1,421,369
Clyde Hill	$-	$-	$-
Covington	$-	$-	$-
Des Moines	$442,349	$-	$442,349
Duvall	$-	$-	$-
Enumclaw	$-	$-	$-
Federal Way	$546,136	$-	$546,136
Hunts Point	$-	$-	$-
Issaquah	$2,129,825	$87,208	$2,217,033
Kenmore	$1,763	$-	$1,763
Kent	$111,849,404	$2,889,295	$114,738,699
Kirkland	$-	$6,902,566	$6,902,566
Lake Forest Park	$1,825,388	$-	$1,825,388
Maple Valley	$-	$-	$-
Medina	$-	$-	$-

	Total Estimated Damages to General Building Stock (Structure and Contents)	Total Estimated Damages to Critical Facilities (Structure and Contents)	Total Estimated Damages
Cities			
Mercer Island	$-	$-	$-
Milton	$-	$-	$-
Newcastle	$-	$-	$-
Normandy Park	$-	$-	$-
North Bend	$10,838,928	$5,284,482	$16,123,410
Pacific	$31,554	$-	$31,554
Redmond	$529,686	$97,755	$627,441
Renton	$14,533,237	$90,370,185	$104,903,422
Sammamish	$2,282,763	$-	$2,282,763
SeaTac	$-	$812	$812
Seattle	$3,152,420	$983	$3,153,403
Shoreline	$-	$-	$-
Skykomish	$2,031,210	$1,231,717	$3,262,927
Snoqualmie	$90,752,421	$6,379,979	$97,132,400
Tukwila	$814,236	$1,029	$815,265
Woodinville	$-	$-	$-
Yarrow Point	$-	$-	$-
Unincorporated King County			
Unincorporated King County	$119,788,513	$6,902,566	$126,691,079
Agricultural Production Districts (APDs)*			
Enumclaw Plateau APD	$20,146,369	$-	$20,146,369
Lower Green River APD	$209,819	$-	$209,819
Sammamish River APD	$-	$-	$-
Snoqualmie River APD	$31,717,317	$1,448,990	$33,166,307
Upper Green River APD	$68,708	$164,470	$233,178

NOTE:
* The values provided for properties in the agricultural production districts (APDs) overlap with the unincorporated King County values.

2.7 Summary of Countywide Flood Hazard and Risks

The previous sections in this chapter describe the flooding characteristics, flooding problems, and other attributes of flood hazard areas in King County. Flooding information is presented by major river watershed, reflecting the different geography, land use, and other characteristics that influence flooding conditions. Information is also presented on flooding conditions for coastal areas, urban areas, and tributary streams. This section provides a high-level summary of the potential impacts of flooding across the county, briefly recaps some of the key points presented in previous sections, and summarizes the results of the countywide flood hazard risk assessment.

Flooding Impacts in King County

Flooding and other flood-related hazards in King County can cause widespread and long-lasting damage. The force of moving floodwaters can tear homes from their foundations, sweep cars off the road, and damage or destroy public infrastructure. Houses and businesses damaged by flooding may become uninhabitable, and, if they can be repaired, repairs can take many months and may displace occupants during that time. Certain types of flooding can leave buildings inundated for several days, which can further worsen property damage. Flood-damaged buildings can pose health risks, including mold and contaminated food and drinking water. In portions of the county without municipal sewer service, flooding can inundate septic systems and cause water quality issues. Additionally, and not to be overlooked, the experience of flooding can cause mental health stress for those affected.

Flooding and flood-related hazards can affect people, property, critical infrastructure, and businesses in different ways. These are summarized as follows:

- **Impacts on People –** Flooding can affect anyone who lives in or near a flood-prone area. Many flood hazard areas in King County are mapped, and people living in mapped 1 percent annual chance floodplains can expect at least a 26 percent chance of seeing floodwaters over 30 years, the length of a typical mortgage. Flooding can threaten lives, particularly in areas where flooding can happen quickly and with little warning, in addition to those driving on flooded roads. Most flood-related deaths occur from people driving through floodwaters and being swept away in their cars.

  Flooding also affects those who work in flood-prone areas or commute through them. Many farmworkers are employed in the Snoqualmie, Sammamish, and Green River valleys, and when flooding inundates or ruins crops, farmworkers can find themselves without jobs. Businesses in floodplains may also shut down during flooding, particularly if buildings and access roads are damaged.

  Vulnerable populations—such as those who do not speak English, do not have easy access to government resources, or cannot afford or do not have flood insurance—are particularly susceptible to the long-term impacts of flooding. Renters can be particularly vulnerable in that they are far less likely to have a flood insurance policy and may not even be aware of their flood risk. Renters may also have less wealth or savings to draw from to pay for uninsured losses.

- **Impacts on Property –** Just a small amount of water inside a building can cause significant property damage and leave building owners or tenants with large repair bills. For families, damage to homes may mean difficult financial decisions, short- or long-term displacement, and lost belongings. For business owners, flood damage may mean lost economic output from closures, destroyed inventory, and the inability to pay employees.

  Throughout King County, at least $5 billion of building value is located within floodplains. Flood insurance, such as federal insurance through the National Flood Insurance Program (NFIP), is the primary way building owners financially protect property in flood-prone areas. Without flood insurance, damage can overwhelm a family's finances, and those without sufficient financial resources will be severely impacted by flood damage to their home and/or belongings.

- **Impacts on the Economy –** A 2007 economic study found that 6 percent of the county's jobs are in floodplains, floodplain businesses generate nearly 7 percent—$3.7 billion—of the county's wages and salaries, and approximately 20 percent of the county's manufacturing employment and 30 percent of the county's aerospace employment are located in floodplains (King County 2007). While new data have not been generated since that time, the study found that a major flood that would shut down economic activity in floodplains would result in at least $46 million per day in lost economic output. The figure is likely much higher today.

  The construction of extensive flood protection infrastructure along the lower Green River and lower Cedar River has allowed significant commercial and industrial development in those areas. The Green River Valley is a regionally significant logistics and distribution hub, and Boeing has a large presence along the lower Cedar River. In the event of a flood that overtops existing flood protection, billions of dollars of economic activity and thousands of jobs are at risk.

  Agriculture is common in King County floodplains, which includes three large Agricultural Production Districts in the lower Snoqualmie Valley, the Sammamish River Valley, and the Green River Valley. Extensive agriculture is also present on parts of the Enumclaw Plateau. Flooding provides nutrients to the soil and supports productive agriculture, but flooding produces negative impacts on agricultural operations, including crop damage and loss, damage to facilities and equipment, and lost productivity.

- **Impacts on Infrastructure, Including Critical Facilities –** A primary impact of flooding in King County is on the transportation network. Certain roadways that cross the lower Snoqualmie Valley are prone to inundation, and some locations and residents can become isolated by flooding. Inundation of sole-access roads presents difficulties for emergency response and can make medical evacuations during times of flooding challenging if not impossible. Repeated roadway inundation also accelerates infrastructure deterioration and increases lifecycle costs, which presents an additional financial burden to constrained local government budgets and, in the case of King County, exacerbates the Roads Division's structural funding crisis.

  In unincorporated King County, five medical facilities are in the 0.2 percent annual chance floodplain (which includes the 1 percent annual chance floodplain) and, of those, only one is located in the 1 percent annual chance floodplain. No hospitals are in the 0.2 percent annual chance floodplain. While these five facilities are at risk, the risk from flooding to the overall healthcare and medical system is low.

Of the 64 police stations in King County, three are in the 0.2 percent annual chance floodplain (in Skykomish, Redmond, and Issaquah). Of the 161 fire stations in King County, six are in the 0.2 percent annual chance floodplain (in Skykomish, Seattle, North Bend, Renton, Issaquah, and near Enumclaw).

Few government facilities are located within flood-prone areas in King County, so flooding does not pose a substantial risk to the continuity of government operations. Certain city buildings in Snoqualmie, North Bend, and Carnation are in flood-prone areas, but some are elevated above the base flood elevation.

Flooding presents risk to wastewater infrastructure, particularly the County's West Point Treatment Plant, which faces risk from king tides and coastal storm systems. Some city wastewater treatment plants are also located in flood-prone areas. Where utility lines cross rivers, flooding can pose problems. For example, the Tolt Pipeline, a water supply line for Seattle, faced risk from the Snoqualmie River migrating toward its alignment. In 2019, a project was completed to provide protection from that risk.

Most communications infrastructure is not vulnerable to flooding, with the primary exception being a regional fiber optic line that runs under the Cedar River Trail and along State Route 169. In some locations, the river abuts the trail, and erosion of the trail prism presents risk to this infrastructure. King County regularly monitors at-risk locations, and the King County FCD has implemented several projects to ensure the continued protection of this significant infrastructure.

Impacts of Past Floods

As mentioned in Chapter 1, King County has experienced 15 federally declared flooding disasters since 1990, the most recent being associated with the February 2020 flood event. Outside of major floods, King County experiences flooding in most years. Many of these flood events result in minor, localized impacts. Some floods are much more severe and result in significant impacts on communities. The following summary describes large flood events occurring since 2013 (the year of the last King County flood plan) and their impacts. These events represent the type of flooding that can be expected in the future in King County.

November 2015 – The November 17-18, 2015, storm was particularly damaging to areas in the South Fork Skykomish River Valley. Extensive flooding was reported throughout the South Fork Skykomish River Valley along U.S. Route 2 in both unincorporated King County and the Town of Skykomish. River flooding was most severe in the west end of the Town of Skykomish along West Riverside Drive, resulting from a poorly designed culvert check valve system, lack of a check valve on an existing culvert, and overtopping of a low section of the containment levee. Flooding was also extensive along Maloney Creek where its banks were overtopped due to high flows, sediment, and debris. Debris accumulated on the Maloney Creek bridge, requiring immediate response to clear the blockage. Impacts from river flooding were magnified by an associated windstorm, causing many trees to fall, blocking U.S. Route 2, and resulting in long-term power outages and property damage. Students at the Skykomish

School had to shelter in place overnight at school without power in the flooded west end of town. Other specific issues and damage included the following:

- Damages to six river facilities.
- Thirteen homes with living space flooding and 12 or more additional homes with basements and crawlspaces inundated in the Town of Skykomish, the Baring neighborhood, Timberlane Village, and other areas.
- Six homes sustained damage from extreme wind and weather or tributary debris flow.
- U.S. Route 2 temporarily closed during the storm, necessitating extensive repair in several locations due to scour at bridges and along roadway embankments.
- Large wood accumulated on Maloney Creek bridge, requiring a response.

December 2015 – In October 2015, flood flows of about 7,500 cfs passed by neighborhoods without impacting residential structures. But in December 2015, the same amount of river flow flooded the overbank areas and inundated houses in White River Estates and many commercial areas along Butte Avenue in Pierce County. The river flooding issues in the Pacific area are acute and exacerbated by the record rainfall, saturating the ground and overwhelming the storm drainage systems.

February 2017 – Significant rainfall in the Seattle area produced extremely high flows into King County's West Point Treatment Plant, and while operating at peak capacity, severe equipment failure occurred. As a result, the treatment plant flooded, and stormwater mixed with untreated sewage was discharged into Puget Sound.

October 2019 – The October 2019 flood event resulted in the loss of livestock, crops, and equipment in the lower Snoqualmie River Valley. A survey done by the Snoqualmie Valley Preservation Association reported flood damages on 26 farms.

January – February 2020 – On January 31, 2020, an atmospheric river arrived in the region bringing heavy and sustained rain. The Tolt River reached the highest flow in over 5 years and other rivers overflowed their banks causing widespread road closures. The more significant impact was that dams on some of King County's major rivers captured large volumes of water that are typically slowly released over several days to make room for the next storm. The next atmospheric river arrived without enough time to allow for sufficient release of water from several of these dams. The combination of prolonged rainy conditions, high river flows, saturated soils, and elevated pools behind dams caused some areas in King County to experience the most severe flooding in decades. By the end of the storm, flooding and landslides had caused severe damage to public and private property, displaced hundreds of people from their homes, and disrupted the lives of people throughout the region. Despite the severity and dangerous nature of the storm, no lives were lost due to flooding.

Due to the persistent rainfall and saturated antecedent conditions, the February 5–11, 2020 flood resulted in more severe lowland inundation and road closures than previous floods at similar river levels. Concerns related to the potential for significant regional road closures led

Eastside Fire and Rescue to request support from the Washington National Guard, which provided a high clearance vehicle to the City of Carnation. The National Guard did not participate in any rescue activities but was on call for 24 hours. Road closures in the Snoqualmie Valley included NE Tolt Hill Road, NE 124th Street, West Snoqualmie River Road NE, and State Route 203 between Fall City and Carnation. Fall City, Carnation, and Duvall remained accessible throughout the flood.

The significant seasonal precipitation and high antecedent soil moisture conditions also contributed to landslide-prone conditions. Landslides were widespread in the Snoqualmie River basin during this event. These conditions, combined with erosive flood flows on the Raging River, led to a landslide at RM 7.14 that threatened a private residence and led to its evacuation and designation as uninhabitable.

Flows in the Cedar River during the February 5–11, 2020, flood were similar in magnitude to the 2009 flood (9,620 cfs at Renton on February 8, which is approximately a 2 percent annual chance flood or 50-year recurrence interval), but remained at a high level for twice the duration (4 versus 2 days over 5,000 cfs) compared to the 2009 flood. Longer durations of high-velocity erosive flows caused extensive flooding and flood-related damage throughout the Cedar River Valley below Landsburg Dam. The event caused the Cedar River to avulse at two locations. The loss of a portion of the Riverbend Lower Revetment at RM 6.85 allowed the river to avulse through Cavanaugh Pond and damage the upstream end of the Cedar River Trail (CRT) Site 2 Revetment. The second avulsion on the Cedar River occurred near RM 16.48 in the Dorre Don neighborhood, where the main flow of the river occupied a left floodplain side channel that could potentially increase bank erosion. Heavy rainfall triggered several landslides throughout the valley that led to temporary road closures, including State Route 169 and closure of the Cedar River Trail within the City of Renton.

Extensive flooding also occurred in the Issaquah Creek basin, resulting in road closures, flooding of homes and businesses, landslides, and damage to many King County levees and revetments throughout the basin. Issaquah Creek reached its highest stage at the Hobart gage since 1996. The downtown core of Issaquah experienced the worst flood conditions since 2009.

The Issaquah Creek basin experienced numerous road damages and closures:

- Issaquah-Hobart Road was closed for several days in both directions to repair flood damage.
- Newport Way SW from Front Street S to Wildwood Boulevard SW was closed due to flooding.
- Newport Way NW from NW Oakcrest Drive to State Route 900 was closed for approximately 1 week due to the threat of landslides.
- State Route 900 from NW Talus Drive to SE May Valley Road was closed.
- Water over Sycamore Drive SE resulted in limited access to the Sycamore neighborhood.

- Three landslides occurred between RM 7.55 and 10.4, ranging from low to high risk; the high-risk landslide resulted in a yellow-tagged home with restricted access.
- More than 200 people were evacuated from three apartment complexes in Issaquah per the City of Issaquah's direction.

Damages also resulted to homes, vehicles, and septic and well systems. This included downed trees that directed overbank flow into a residence, flooded the crawlspace, and put the wellhead at risk. Other home and outbuilding damage also occurred.

The February 2020 flood resulted in the highest recorded level on Lake Sammamish (elevation 31.2 feet) since construction of the Sammamish River flood project in 1965. Flood impacts along the Sammamish River, while minor during the February event, were more noticeable in Redmond and diminished downstream. Whereas flows in Bothell began to recede days after the peak precipitation, flooding along the river in Redmond and in Marymoor Park persisted for nearly 1 week due to sustained inputs from Bear Creek that inhibited and delayed outflows from the lake.

December 2022 – The peak of December king tides and a very strong low-pressure system moving through Western Washington occurred simultaneously, and the result was the water level of Puget Sound peaking at 3.76 feet above the normal mean higher high water (MHHW) mark. Estimates determined that the astronomical king tide produced a tide that was 1.53 feet above the normal MHHW mark, and the low-pressure system added another 2.23 feet above the predicted king tide. The resulting water level surpassed the previous record of 3.16 feet above MHHW set in January 2022 and resulted in major coastal flooding throughout the Puget Sound region. In King County, impacts were seen in numerous locations along the marine shoreline but were especially significant in the South Park neighborhood on the lower Duwamish River and along the shoreline of Vashon-Maury Island.

Countywide Flood Hazard Risk Assessment

To better understand flood risk within King County, a countywide flood hazard risk assessment was performed using FEMA's Hazus Risk Assessment Platform (Version 6.0). Hazus calculates losses to structures due to inundation by looking at depth of flooding and structure types. Using historical flood insurance claim data, Hazus can estimate the percentage of damage to structures and their contents by applying established damage functions to an inventory of structures.

King County's analysis evaluated the risk from flooding for the 10-, 5-, 2-, 1-, and 0.2 percent annual chance flood events faced by the general building stock (all structures), critical facilities, and repetitive loss properties. The results of the analysis present both exposure to flooding (number of structures and dollar value of structures and contents that fall within flood hazard areas) and estimated damage from the specified flood events (dollar-value estimates of potential structure and contents damage, determined using flood depth data and known property replacement cost values). Best available data were used in the analysis, including parcel and structure information from King County's Geographic Information System (GIS) data hub,[8] the King County Assessor, and flooding information from King County and FEMA. The analysis included all incorporated and unincorporated areas within King County.

Earlier subsections in this chapter present exposure and estimated damage information by geography. The tables that follow (**Table 2.7-1** through **Table 2.7-7**) present aggregated county-level information. While these data help assess the magnitude of exposure to flooding and the potential damage that could result, it is important to keep in mind that this analysis represents general approximations and is a simplified assessment of flood risk. Furthermore, the unique nature, geographic extent, and severity of each flood event means that not all areas experience flooding in the same way each time a flood occurs. The potential exposure and loss estimates provided in the tables below are approximate and should be used only to understand relative risk.

TABLE 2.7-1
SUMMARY OF ASSETS IN KING COUNTY

Asset Type	Total Number of Structures	Total Structure Value	Total Content Value
General Building Stock	716,919	$529,771,821,643	$330,124,585,742
Critical Facility	7,878	$41,346,749,136	$35,150,703,096
Repetitive Loss Property	187	$80,088,352	$48,009,425

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TABLE 2.7-2
COUNTYWIDE EXPOSURE OF BUILDINGS LOCATED IN KING COUNTY

Flood Event	Number of Structures Exposed	Total Structure Value Exposed	Total Content Value Exposed
10-year – Riverine	5,453	$4,860,375,948	$3,830,123,225
10-year – Coastal	5	$4,509,914	$3,232,414
50-year – Riverine	5,491	$4,874,864,605	$3,838,216,669
50-year – Coastal	5	$4,509,914	$3,232,414
100-year – Riverine	10,885	$11,907,318,847	$10,233,604,608
100-year – Coastal	860	$705,720,136	$499,572,903
500-year – Riverine	13,987	$15,334,703,166	$13,037,237,111
500-year – Coastal	1,161	$930,346,325	$653,098,527

8 https://kingcounty.gov/en/legacy/services/gis/gisdata.

The exposure analysis determined that approximately $1.7 billion of structural value for critical facilities is at risk to riverine flooding up to the 0.2 percent annual chance flood event. These critical facilities have a content value of approximately $2.1 billion. Additionally, approximately $26.9 million of structural value for critical facilities is at risk to coastal flooding up to the 0.2 percent annual chance flood event. These critical facilities have a content value of approximately $35.0 million.

TABLE 2.7-3
COUNTYWIDE EXPOSURE OF CRITICAL FACILITIES LOCATED IN KING COUNTY

Flood Event	Number of Critical Facilities Exposed	Total Structure Value Exposed	Total Content Value Exposed
10-year – Riverine	335	$665,248,786	$894,393,151
10-year – Coastal	0	$0	$0
50-year – Riverine	338	$665,677,786	$895,036,151
50-year – Coastal	0	$0	$0
100-year – Riverine	498	$1,268,527,576	$1,626,431,506
100-year – Coastal	26	$25,661,291	$33,213,049
500-year – Riverine	574	$1,656,824,335	$2,127,750,883
500-year – Coastal	27	$26,863,436	$35,016,266

The exposure analysis determined that approximately $71.9 million of structural value for repetitive loss properties is at risk to riverine flooding up to the 0.2 percent annual chance flood event. These repetitive loss properties have a content value of approximately $43.9 million. Additionally, approximately $1.6 million of structural value for repetitive loss properties is at risk to coastal flooding up to the 0.2 percent annual chance flood event. These repetitive loss properties have a content value of approximately $800,000.

TABLE 2.7-4
COUNTYWIDE EXPOSURE OF REPETITIVE LOSS PROPERTIES LOCATED IN KING COUNTY

Flood Event	Number of Repetitive Loss Structures Exposed	Total Structure Value Exposed	Total Content Value Exposed
10-year – Riverine	151	$64,984,603	$39,684,926
10-year – Coastal	0	$0	$0
50-year – Riverine	151	$64,984,603	$39,684,926
50-year – Coastal	0	$0	$0
100-year – Riverine	162	$70,026,646	$42,740,447
100-year – Coastal	4	$1,565,000	$782,500
500-year – Riverine	165	$71,929,896	$43,930,197
500-year – Coastal	4	$1,565,000	$782,500

Hazus estimates up to $700 million in structural damages and up to $507 million in content damages to buildings from the 0.2 percent annual chance riverine flood. Additionally, Hazus estimates up to $58.6 million in structural damages and up to $66.6 million in content damages to buildings from the 0.2 percent annual chance coastal flood. Due to data limitations in the flood depth information available to support the analysis, the results for the 1 percent annual chance flood event appear lower than the results for the 5 and 2 percent annual chance flood events. However, actual damages from a 1 percent annual chance flood event are likely to be significantly higher than for the 5 or 2 percent annual chance flood events.

TABLE 2.7-5
COUNTYWIDE DAMAGES OF BUILDINGS LOCATED IN KING COUNTY

Flood Event	Total Structure Value Damages	Total Content Value Damages
10-year – Riverine	$313,490,496	$134,430,093
10-year – Coastal	$111,530	$376,163
25-year – Riverine*	$348,870,082	$164,564,546
25-year – Coastal*	$111,855	$377,174
50-year – Riverine	$407,836,059	$214,788,636
50-year – Coastal	$112,397	$378,858
100-year – Riverine	$165,802,623	$202,700,222
100-year – Coastal	$50,591,679	$63,068,835
500-year – Riverine	$699,808,925	$507,049,406
500-year – Coastal	$58,615,284	$66,642,954

NOTE:
* 25-year flood event values were linearly interpolated between the 10- and 50-year flood results modeled for each structure.

Hazus estimates up to $84.5 million in structural damages and up to $18.3 million in content damages to critical facilities from the 2 percent annual chance riverine flood. Additionally, Hazus estimates approximately $250,000 in structural damages and approximately $250,000 in content damages to critical facilities as a result of the 1 percent annual chance coastal flood. The same data limitation described above applies to these results; thus, additional study may be useful to better understand the vulnerability of critical facilities to flooding.

TABLE 2.7-6
COUNTYWIDE DAMAGES OF CRITICAL FACILITIES LOCATED IN KING COUNTY

Flood Event	Total Structure Value Damages	Total Content Value Damages
10-year – Riverine	$83,148,718	$13,066,297
10-year – Coastal	$0	$0
25-year – Riverine*	$83,638,966	$15,016,490
25-year – Coastal*	$0	$0
50-year – Riverine	$84,456,046	$18,266,811
50-year – Coastal	$0	$0
100-year – Riverine	$39,502,277	$75,032,944
100-year – Coastal	$249,306	$247,803
500-year – Riverine	$46,921,760	$89,218,285
500-year – Coastal	$89,456	$247,803

NOTE:
* 25-year flood event values were linearly interpolated between the 10- and 50-year flood results modeled for each structure.

Hazus estimates up to $27.2 million in structural damages and up to $15.8 million in content damages to repetitive loss properties from the 0.2 percent annual chance riverine flood. Additionally, Hazus estimates up to $55,000 in structural damages and up to $23,000 in content damages to repetitive loss properties as a result of the 0.2 percent annual chance coastal flood.

TABLE 2.7-7
COUNTYWIDE DAMAGES OF REPETITIVE LOSS PROPERTIES LOCATED IN KING COUNTY

Flood Event	Total Structure Value Damages	Total Content Value Damages
10-year – Riverine	$4,815,178	$2,409,442
10-year – Coastal	$0	$0
25-year – Riverine*	$8,504,655	$4,528,211
25-year – Coastal*	$0	$0
50-year – Riverine	$14,653,784	$8,059,492
50-year – Coastal	$0	$0
100-year – Riverine	$14,899,809	$9,755,949
100-year – Coastal	$55,146	$23,262
500-year – Riverine	$27,152,762	$15,839,880
500-year – Coastal	$55,146	$23,262

NOTE:
* 25-year flood event values were linearly interpolated between the 10- and 50-year flood results modeled for each structure

CHAPTER 3

Review of Flood Risk Reduction Activities

This chapter identifies and describes various flood risk reduction tools, approaches, and strategies—collectively referred to as "activities"—that King County considered to meet the goals and objectives of this Flood Plan. FEMA identifies six categories of activities to be considered in a flood plan, as follows:

- **Prevention –** Includes floodplain mapping and regulations, open space conservation, stormwater management, building codes, and other activities intended to prevent harm or prevent existing problems from getting worse.
- **Property protection –** Acquisition, relocation, building elevation, insurance, and other activities that apply to specific parcels or buildings.
- **Natural resource protection –** Protection and restoration of natural areas and functions, improvement of water quality, and any other actions intended to preserve or restore the natural functions of floodplains and watersheds.
- **Emergency services –** Emergency preparedness and preparedness communications, emergency response planning, flood warning and response, critical facilities protection, post-disaster mitigation, and other measures taken during an emergency to minimize the impact.
- **Structural projects –** Construction or maintenance of levees, floodwalls, and revetments, or modifying channels to divert floodwaters away from specific areas.
- **Public information –** Outreach, education, technical assistance, and other means of advising property owners and community members about flood hazards, the resources available to prepare for flooding, and the actions individuals can take to improve their resilience to flooding.

The purpose of this chapter is to describe the risk reduction activities considered during the planning process to address King County's flood and channel migration hazards identified in the previous chapter, consistent with FEMA's Community Rating System, Step 7. The Flood Plan Partner Planning Committee evaluated activities for each of the six categories listed above; during the community outreach and engagement activities, community members were asked for input on the six categories through the online survey and in-person events.

King County community engagement and education table at Sea Mar Fiestas Patrias, September 2023

This chapter includes many activities King County currently implements and notes where currently implemented activities have room for improvement. This chapter also summarizes other ideas King County considered to address the flooding and channel migration risks identified in this Flood Plan. **Appendix J** includes additional documentation of the review of the six categories of flood risk reduction activities.

3.1 Prevention

Several tools are actively used by King County and other local governments within the county to prevent flood problems from occurring or to prevent problems from getting worse. Prevention activities considered during this planning process include producing flood hazard and channel migration maps and other studies to identify the extent of flood and erosion hazards; developing, updating, and enforcing land use regulations and development standards; preserving open space; considering the effects of climate change; and managing stormwater runoff. This section describes the ways King County can use these tools, and the opportunities to modify practices to improve the efficacy of these tools.

Floodplain and Flood Hazard Mapping and Information

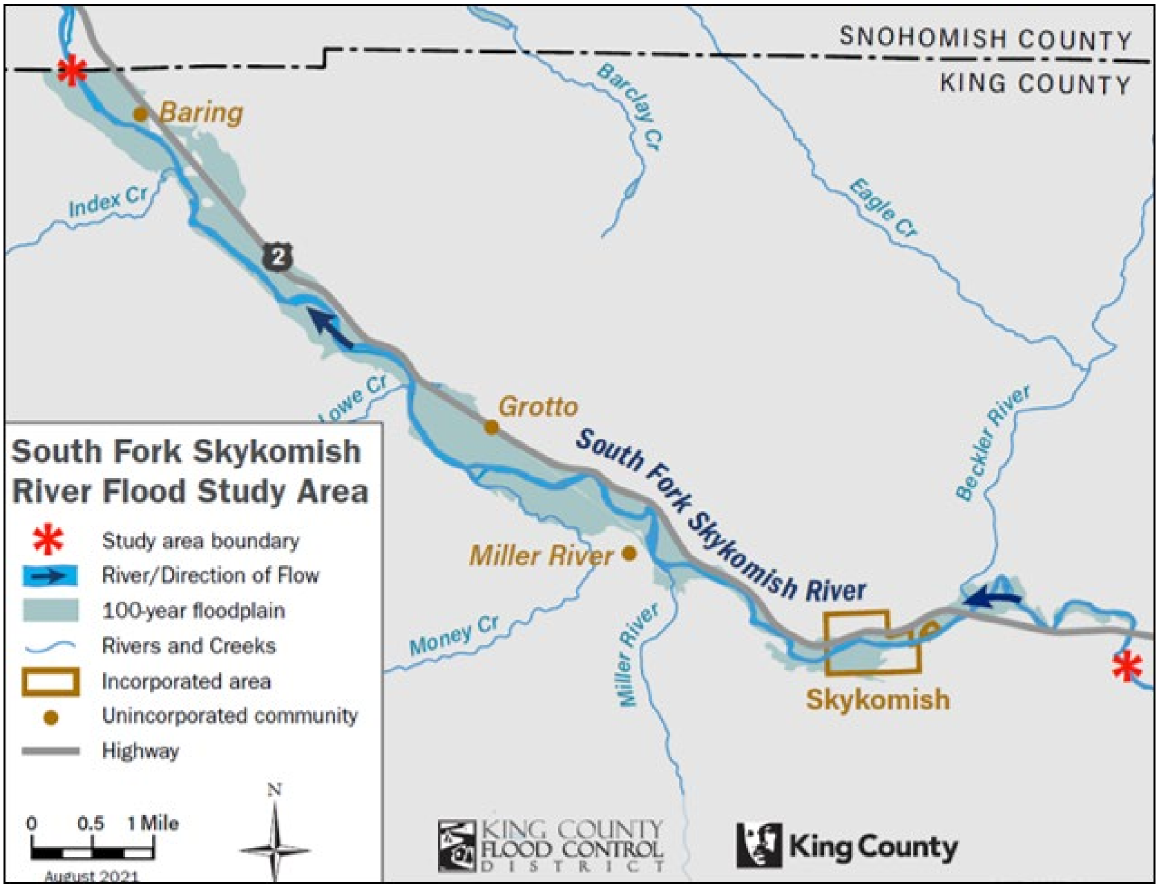
Technical analyses of watershed hydrology, river channel hydraulics, channel and floodplain topography and hydrography, fluvial geomorphology, and geology and soils are essential tools for flood hazard management. These analyses provide the information necessary to delineate areas subject to flooding and flood-related hazards, assess and understand risks, inform land use regulations and zoning, and develop solutions to address identified risks. Analyses can also be used to evaluate effects on and changes to flood hazard areas from proposed projects or development activities.

What King County heard

Community members and partners coupled requests for expanding existing flood hazard mapping with improved sharing of those resources. Expanded mapping related to hazards in areas where floodplains have not been delineated. Requests for new flood hazard mapping often focused on urban areas impacted by localized flooding, which are areas not affiliated with a river, not typically mapped, and often not regulated as flood hazard areas. Other suggestions focused on mapping other hazards that relate to flooding, such as mapping alluvial fan hazards and landslide areas.

King County uses a range of technical information to characterize, quantify, and delineate flood hazards and related risks and, in turn, uses the information to develop and implement activities to reduce risk. The types of technical information that King County uses to inform flood risk reduction activities include topographic and ortho imagery data collection, hydrologic and hydraulic studies, floodplain and channel migration zone mapping, geologic studies, river channel elevation monitoring, GIS land use data, habitat studies, dam operations studies, risk assessments, and working maps of flood hazard management corridors. Ongoing coordination with state and federal agencies and academic researchers that collect and update scientific information is essential to accurate flood hazard identification and communication.

Many city governments in King County employ similar tools to understand risks along smaller tributary streams within their jurisdictions, yet smaller jurisdictions reported during the planning process that they have limited resources with which to fund extensive technical analyses. Some larger cities are in better position to fund flood-related technical analysis. In addition to studies related to the operation of the City of Seattle's water supply dams on the Tolt and Cedar rivers, the city has completed other studies focused on flooding and climate change impacts, including assessments of creek flooding, extreme weather events, and sea level rise. Where smaller jurisdictions are resource-limited, partnerships are an important way to develop and update flood maps for streams in incorporated areas.



Example of flood hazard area mapping, South Fork Skykomish Flood Study 2021

Flood hazard area maps are tools to inform the public of potential flood hazards, and they form the basis for land use regulations focused on reducing existing risks and preventing future risks. King County continues to emphasize updating flood hazard data and mapping for the county's major rivers and some tributaries. Maps are also being developed for other tributaries as resources become available, with much of this work currently funded by the FCD. King County currently has a mapped and regulated coastal high-hazard area and sea level rise risk area, and, in 2014, amended its critical areas code (Chapter 21A-24) to establish criteria for the designation, classification, and mapping of channel migration zones, which is an ongoing body of work. The status of flood hazard and channel migration zone mapping since the completion of the 2013 Flood Plan Update is presented in tables in **Appendix I**.

When complete, flood hazard and channel migration maps are adopted by their respective regulatory agencies (local communities and/or and King County Department of Local Services) and then made available on King County's website, on the interactive King County iMap online mapping tool, and at King County libraries in hard copy.

In 2016, King County completed river corridor landslide hazard mapping (funded by the FCD) to identify areas where the occurrence and potential exists for deep-seated landslides, shallow debris slides, fans, rockfall, and rock avalanches. Where these hazards occur along river corridors, this indicates where a landslide could partially or completely block a river channel and cause unexpected and potentially catastrophic flooding. Specifically for deep-seated slides, the mapping identifies locations where deep-seated landslides are subject to toe erosion by river forces. This mapping provides emergency service providers and residents with valuable preparedness information and helps project managers understand where they need to consider risks from landslides and landslide-related flood hazards.

For areas outside of the river corridor landslide areas mapped in 2016, published geologic mapping by the Washington Geologic Survey and USGS identifies landslides, fans, and debris flow hazards that present potential flood-related landslide risks.

Climate Change Analysis

Although they are useful tools, flood hazard maps represent a snapshot in time and are often based on historical records and conditions at the time the mapping is completed. As land use and physical conditions change, modeling can become less representative of current conditions. Moreover, regional climate projections are indicating that changes in precipitation patterns in Western Washington in the future, as well as sea level rise, will likely result in larger floods than are typically considered in flood risk reduction planning. As a result, existing flood hazard area maps likely understate future flooding conditions.

As new maps are developed or existing maps are updated, incorporating new data about climate change will be essential to more accurately portray future flood risk. The current mapped 0.2 percent annual chance flood event can be used to preview what the future 1 percent annual chance flood event could look like, but expanding quantitative analysis to be more explicit about potential river or basin-scale changes in risks due to future projected flows is a needed area of investigation. During the planning process, partners and the public expressed support for increased analysis of how climate change will affect flooding.

King County Comprehensive Plan

King County's first comprehensive plan dates to 1964 and has been revised many times. Following the 1990 passage of the Washington State Growth Management Act (GMA), King County revised its comprehensive plan in 1994 for GMA consistency. Comprehensive plans adopted in accordance with GMA must manage growth so that development is directed to designated urban areas and away from rural areas. The GMA also requires jurisdictions to designate and protect critical areas, including frequently flooded areas and channel migration zones. Comprehensive plans must also identify and protect natural resource lands.

The Comprehensive Plan is developed consistent with the King County Countywide Planning Policies, which create a shared and consistent framework for growth management planning for all jurisdictions in King County. RCW 36.70A.210[1] requires the legislative authority of a county to adopt a countywide planning policy in cooperation with cities located in the county.

1 https://app.leg.wa.gov/rcw/default.aspx?cite=36.70A.210.

The 2021 King County Countywide Planning Policies include several policies related to flood risk reduction and integrated approaches to environmental protection:

- EN-6: Locate development and supportive infrastructure in a manner that minimizes impacts to natural features. Promote the use of traditional and innovative environmentally sensitive development practices, including design, materials, construction, and ongoing maintenance.
- EN-7: Coordinate approaches and standards for defining and protecting critical areas, especially where such areas and impacts to them cross jurisdictional boundaries.
- EN-8: Use the best available science when establishing and implementing environmental standards.
- EN-12: Coordinate and fund holistic flood hazard management efforts through the King County Flood Control District.
- EN-13: Work cooperatively to meet regulatory standards for floodplain development as these standards are updated for consistency with relevant federal requirements including those related to the Endangered Species Act.
- EN-14: Cooperate with federal, state, and regional agencies and forums to develop and implement regional levee maintenance standards that ensure public safety and protect habitat.

The Comprehensive Plan is the County's legal framework for land use in unincorporated King County and is the guiding document for functional plans and development regulations. As of the time of the drafting of this Flood Plan, the Comprehensive Plan is undergoing a major 10-year update (2024 Update). As part of the 2024 Update, King County updated its Best Available Science (BAS) as required by GMA. The BAS update aims to ensure compliance with current GMA requirements, with a greater emphasis on achieving no net loss of critical area functions and values. It also seeks to incorporate significant state agency updates to BAS for riparian areas and wetlands while bolstering local management and protection of critical areas.

King County is using the BAS update to inform updated policies and development regulations. Regulatory updates in progress as of the drafting of this Flood Plan include updates to the critical areas regulations applied to wetlands, riparian areas, geologically hazardous areas, and frequently flooded areas. These include provisions to support multi-benefit flood risk reduction and fish passage projects, both of which are key elements of King County's salmon recovery strategy.

The Flood Plan is adopted as a functional plan of the Comprehensive Plan and, as such, it details Comprehensive Plan policies for the protection of frequently flooded areas and floodplain management. In many cases, the Comprehensive Plan points to the Flood Plan for floodplain management and flood risk reduction focused policies.

King County Code Title 20 is the planning code and is the title that adopts the County's Comprehensive Plan for compliance with the GMA. King County Code 20.12.480 adopts the King County Flood Management Plan as a functional plan to guide flood hazard management in King County.

Zoning Ordinance

> **What King County heard**
>
> Community members uniformly stated that new development should be managed carefully to prevent making flooding worse for others, including comments in favor of tighter restrictions or limitations in incorporated towns and cities and unincorporated King County. Some specific suggestions included incentivizing more density in development outside of floodplains, increasing resilient design standards, and regulating potential future flood hazard areas. Easing permitting for home resilience improvements was also discussed by some parties.

King County's zoning ordinance (King County Code Title 21A) guides the application of land use regulations within each of several zoning classifications and is accompanied by zoning maps that illustrate zones for agriculture, forestry, industrial, rural areas, urban areas, regional business areas, and others. Zoning regulations describe allowable activities within each of the zones, which are then subject to additional land use and development regulations that guide activities in flood hazard areas. The zoning ordinance reduces future flood losses by establishing buffers and setbacks for aquatic areas and wetlands, requiring clustered developments away from critical areas, and creating natural open space for the conservation of floodplains and other critical areas. King County's zoning ordinance identifies the regulatory floodplain (including the coastal high-hazard area), channel migration zones, wetlands, and landslide hazard areas as critical areas. Cities in King County also have their own zoning ordinances to guide land use activities within their boundaries.

King County's zoning code contains most of the development regulations for construction within floodplains and other critical areas. King County Code Title 21A.06 contains definitions of terms used in the zoning code. The floodplain development regulations are located within Title 9 (Surface Water Management), Title 13 (Water and Sewer Systems), Title 16 (Building and Construction Standards), and Title 21A (Zoning).

King County's Shoreline Master Program, adopted in 1975, underwent its first major update in 2011. The 2011 update included a characterization of all of King County's shorelines of the state, created new shoreline environmental designations, and developed policies for activities and uses within each designation. Regulations implementing the shoreline policies are codified in King County Code Title 21A.25. Flood risk reduction activities must comply with the Shoreline Master Program and shoreline regulations in King County Code Title 21A.25. The zoning code is enacted to be consistent with and implement the Comprehensive Plan in accordance with Chapter 36.70A of the RCW.[2]

Flood Hazard Area Land Use and Development Regulations

- Regulation of land uses in flood hazard areas can be one of the most effective ways of reducing the risk from flooding and channel migration. Land use regulations specify the allowable development in flood hazard areas. Development standards complement those regulations by ensuring that allowable development is done in ways that further limit risk and flood losses to structures.
- King County's flood hazard area regulations for unincorporated areas are in King County's Critical Areas Ordinance, which was adopted in 2004 and is codified in King County Code Title 21A.24. The County's flood code was most recently updated in 2020. King County's flood-related land use regulations describe the types of activities that are allowed in flood hazard areas, channel migration zones, coastal high-hazard areas, and sea level rise risk areas. King County applies the 2021 Washington State Building Code, which guides how structures are to be constructed to limit the risks presented by flood-related hazards.

Allowable uses and standards under King County's regulations vary by location within the flood hazard area, but all standards are intended to reduce risk by exceeding the minimum standards of the NFIP. King County has adopted several regulations that exceed the minimum NFIP standards and effectively reduce future flood losses:

- A 3-foot freeboard (height above the base flood elevation) standard for new or substantially improved structures and critical facilities.
- Requirement to provide compensatory storage at the same elevation for fill placed in the floodplain.
- A zero-rise standard throughout the zero-rise floodway to preserve flood conveyance.
- Restrictions on development in areas where depths exceed 3 feet and velocity exceeds 3 feet per second.
- Requirement for new lots to have at least 5,000 square feet outside the zero-rise floodway.
- Restriction on nonresidential structures in the FEMA floodway, with some exceptions for agricultural buildings.
- Standards for manufactured home parks located in the floodplain.
- Requirement to remove temporary structures and hazardous materials from the floodplain during the flood season.
- Restriction on critical facilities in the zero-rise floodway and FEMA floodway.
- Density restrictions in portions of the floodplain under land use and critical areas protection measures.

[2] https://app.leg.wa.gov/rcw/default.aspx?cite=36.70a.

- Regulation of development within channel migration zones and unmapped flood hazard areas.

Additionally, in July 2020, King County adopted a Sea Level Rise Risk Area and associated changes to local land use codes for Vashon-Maury Island to reduce the risks of sea level rise on shoreline development.

Many cities in King County have mapped flood hazard areas, and 37 of the 39 incorporated municipalities participate in the NFIP (FEMA 2023). While floodplain development regulations exist in these communities, regulations are not consistent across all jurisdictions.

King County's expanded floodplain regulations beyond NFIP minimum standards (in particular, compensatory storage and the zero-rise floodway) provide enhanced protection from flooding for people and property but present conflicts with restoring critical habitat for salmonids protected by the Endangered Species Act (ESA). Current standards protect existing floodplain functions and habitat, but they maintain the status quo of degraded conditions and limit King County's ability to reconnect and restore floodplain functions in a way that provides flood risk reduction and habitat benefits. An area for future work is collaboration with federal and state agencies, tribes, and community partners to better align federal minimum standards for flood hazard regulations with ESA requirements for protection and recovery of listed salmonid species and tribal rights. This will allow King County to continue to reduce flood risk for people and property while improving the effectiveness of salmon recovery actions.

Building Codes

King County Code Title 16 is the County's building and construction standards code. King County has adopted the International Building Code, the International Residential Code, the International Property Maintenance Code, the International Mechanical Code, and the International Security Code. These codes have all been amended by the state of Washington for application in the state, including amendments to ensure compliance with the Washington state floodplain management regulations.

King County has made additional amendments to these codes for application within the county to ensure that the County's higher regulatory floodplain standards are maintained. One example of a higher regulatory standard to prevent future flood losses is the requirement that under-construction elevation certificates must be certified by a professional licensed surveyor confirming the foundation's 3 feet of freeboard. Those sections of the International Codes that are inconsistent with state or local regulations have either not been adopted or have been amended. When implemented in conjunction with higher regulatory standards, King County's building codes help to ensure that structures are sufficiently resilient for current and future conditions.

Subdivision Ordinance

A subdivision ordinance regulates the development of residential, commercial, industrial, or other uses, including associated public infrastructure, as land is subdivided into buildable lots for sale or future development. Subdivision design that accounts for natural hazards can dramatically reduce the exposure of future development.

Title 19A of the King County Code establishes the procedures for subdividing land, consistent with the policies of the King County Comprehensive Plan and the critical areas regulations outlined in Title 21A.24.

Per King County Code 21A.24.240, subdivisions must be consistent with the need to minimize the potential for flood damage in flood hazard areas. Requirements for new building lots are:

- 5,000 square feet or more of buildable land must be outside of the zero-rise flood fringe.
- Utilities must be elevated or dry floodproofed to or above the flood protection elevation.
- Base flood elevations, required flood risk reduction elevations, floodplain and floodway boundaries, and channel migration zone boundaries must be identified, and setbacks restrict structures to suitable buildable areas.
- Adequate drainage away from building sites must be provided.
- Notice for any site that is in a floodplain and for which emergency access may not be available during flood events must be provided.
- Taken together, these requirements serve to reduce the likelihood of flood risk for new building lots.

Stormwater Management Regulations

Stormwater runoff results when water is unable to soak into the ground due to either impervious surfaces or saturated soils that prevent infiltration. As land becomes more developed, the amount of stormwater increases. Without intervention, stormwater runoff can cause flooding that results in direct impacts on people and property, as well as damage to river and stream systems and destruction of habitat needed by fish and wildlife. Stormwater can also transport contaminants into county waterways, which can harm fish and wildlife and degrade water quality.

What King County heard

Stormwater management was a major concern among community members and partners. Low-impact development requirements and incentives, such as rain gardens, were emphasized as important strategies for reducing stormwater runoff. Stormwater runoff impacting lower watershed communities also generated discussion of the potential for stormwater management planning at a basin level, instead of at a jurisdiction-level.

An extensive regulatory landscape attempts to manage stormwater and reduce its impacts, which informs cities within the county as they implement surface water management programs. King County's *Surface Water Design Manual* is a technical guide that outlines requirements for stormwater management systems in King County. It regulates proposed surface and stormwater projects through a mixture of best management practices (BMPs), performance standards, and design standards. In unincorporated King County, drainage review and approval of designs during the permitting process ensures these standards are being applied, which are governed not only by King County Code but, to some extent, by the County's National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit, which contains specific requirements for drainage review and inspection of development projects. In addition to the manual's standards being applied throughout the unincorporated areas, many cities throughout King County have adopted the manual and apply its standards as part of their local permitting processes.

To comply with the Phase I Municipal Stormwater Permit under the NPDES of the Clean Water Act, King County implements a Stormwater Management Program Plan (SWMP Plan). The SWMP Plan is updated annually and guides the many activities King County implements to manage stormwater. These include mapping the municipal stormwater system, coordination among county departments to eliminate barriers to compliance with stormwater requirements, controlling runoff from new development and redevelopment, updating design standards and stormwater management regulations, and operations and maintenance of the stormwater system.

Title 9 of the King County Code is the County's Surface Water Management Code, and it supplements the King County *Surface Water Design Manual* and individual basin plans, which are adopted in Title 20. King County Code Title 9.04 is developed to promote the public health and safety by providing for comprehensive management of stormwater runoff and surface water and erosion control, especially to preserve the many values of the county's natural drainage system, including open space, fish and wildlife habitat, recreation, education, and urban separation.

Title 9 identifies that King County will carry out programs to reduce flooding, erosion, and sedimentation; prevent and mitigate habitat loss; enhance groundwater recharge; and prevent water quality degradation through the implementation of comprehensive and thorough permit review, construction inspection, enforcement, and maintenance. State funding authorities for stormwater management are focused on the local jurisdiction rather than watershed level, with each city or county enacting its own Surface Water Management fee, and use of that fee subject to limitations under state law. State regulatory frameworks under the Clean Water Act and NPDES are also highly localized, with accountability at the level of individual municipality. The focus of stormwater regulatory compliance and funding on individual jurisdictions can create barriers to watershed or regional approaches to addressing stormwater flooding.

Open Space Conservation

- While regulations limit development in flood hazard areas, new development, even done in ways consistent with current regulations, can lead to landscape changes that may have consequences in terms of safety and damage in the future. Protecting open space, through acquisition or easement, is a proactive way to prevent future flood risks from occurring (note that acquisition of developed property is covered later, under Property Protection).

As a local government, King County has a long history of land conservation and protection. Since 1970, King County has conserved close to 200,000 acres of land to protect rivers and streams, provide habitat for wildlife, support recreational opportunities, ensure farms and working forests can remain viable, and provide open space access to local communities. While options for conserving open space within the urban growth area are somewhat limited, many local governments recognize the value of open space for flood risk reduction and general community benefit and pursue protection opportunities where they exist.

In 2016, King County launched the Land Conservation Initiative (LCI), a regional collaboration among King County, cities, businesses, farmers, environmental partners, and others to accelerate land acquisition to protect the remaining high-value conservation lands within 30 years. The LCI prioritizes the conservation of 65,000 acres across six land categories, one of which is river corridors, where property acquisition is used to reduce flood risk and support viable populations of native Pacific salmonids.

Open space conservation provides many flood risk reduction benefits:

- For land adjacent to rivers and streams, conservation allows room for floodwaters to spread out, dissipate, and infiltrate, which can be a valuable way to reduce flood risks to adjacent or downstream properties.
- Protecting lands in upper watershed areas can help alleviate downstream flooding impacts by moderating runoff and the timing of water reaching river and stream channels.
- Protecting and preserving intact wetlands helps moderate flood flows and provides floodwater storage.
- Open space conservation is a permanent solution. Once lands are protected through fee acquisitions, they remain protected in perpetuity; once development rights have been removed from title, the land cannot be developed in a way that would introduce new risk, allowing the land to provide natural flood risk reduction benefits.

Property value increases throughout the county have made acquiring land much more costly in recent years, but several funding mechanisms are in place to support the acquisition of open space:

- King County Conservation Futures
- King County Parks Levy

- State and federal grants
- Transfer of development rights
- In-lieu fee mitigation funding

3.2 Property Protection

Property protection measures focus on reducing risk to existing structures or removing structures from flood risk areas and are typically implemented at the parcel scale. Options to reduce risk through protection include retrofitting structures (such as elevation or floodproofing), acquisition and demolition of structures, or relocation, all of which are effective means of reducing or preventing risks to structures and their occupants without constructing or upgrading flood protection facilities. Flood insurance, while not addressing underlying risk, provides a measure of protection and supports flood resilience by providing coverage against losses. Sandbagging is a very temporary measure but can reduce immediate risk and is low cost.

Property protection activities are effective, and they can provide multiple benefits. They also can provide long-term cost savings by reducing flood insurance claims, reducing or eliminating the need for flood protection facilities, and reducing public expenditures for emergency response and the risk to emergency responders. In some cases—and especially in the case of acquisitions and relocations—these activities allow floodplain and channel migration areas to be reconnected to the river, providing opportunities for improved habitat and ecosystem function, and may reduce risk to nearby areas.

Elevations

Structural elevation projects involve raising the finished floor of a structure above the base flood elevation to reduce the potential for flood damage. In King County, elevations are typically implemented for residential structures, but agricultural buildings have also been elevated. King County Code 21A.24.240 defines the requirements for development in flood hazard areas, including elevations. The lowest habitable floor must be raised at least 3 feet above the elevation of the 1 percent annual chance flood or 1 foot above the elevation of the 0.2 percent annual chance flood, whichever is higher. Home elevation projects allow property owners to maintain their homes in their existing location, thereby preserving neighborhoods and historic buildings and avoiding added pressure on housing resources.

What King County heard

Two of the most widely requested property protection actions were technical assistance to support landowners in transitioning to land uses that better accommodate flooding, and retrofitting or elevating buildings. Supporters of this strategy hoped to see more home elevations on agricultural landscapes and in coastal areas. Most community members supported acquiring at-risk properties, and some raised concerns about the negative equity impacts of these programs.

Elevation activities can provide long-term risk reduction benefits but do not eliminate risk. They are appropriate in areas where structures are subject to low-velocity floodwaters, but they are not a viable alternative in areas subject to high-velocity flows, bank erosion, channel avulsion, or landslide hazards due to the potential for stranding, undermining, collapse, or other damage to the structure. Temporary access issues may remain in the case of flooded roadways. Clean water access may be compromised, utilities (including septic systems) may flood, and emergency services may be unable to reach the residents.

Elevated home in Snoqualmie River Watershed during floods, November 2006

Elevation projects implemented in King County have reduced flood risk, yet the program could be adjusted to expand its effectiveness. For example, home elevations are almost exclusively implemented in the Snoqualmie River basin. While parts of this basin are an ideal setting for elevations due to low-velocity, deep floodwaters, other locations in the county may also be appropriate for this mitigation activity. The program could be expanded to provide incentives for permittable home elevations in all floodplains and repetitive loss areas of King County. In some cases, demolishing and rebuilding a home may be a more suitable and financially beneficial option. This could be incentivized like home elevation projects to reduce flood risk.

The program as currently implemented requires that property owners have sufficient capital to cover significant costs prior to being reimbursed. This presents equity issues since some homeowners are unable to afford the initial financial outlay. King County has assisted property owners with home elevations by securing and administering grants and loans from federal, state, and local hazard mitigation and housing assistance programs. In recent years, the FCD has been a primary source of funds for home elevations, yet property owners are limited in their ability to assemble the necessary matching funds.

While not a structural elevation, construction of farm pads—raised mounds of earth that provide refuge for livestock and storage of equipment during times of flooding—is an approach desired by famers, particularly in the Snoqualmie Valley. Some farm pads were constructed in the valley in past years, but investigation of existing floodplain conditions and compensatory storage requirements is needed to determine whether additional farm pad implementation is a possibility in the future.

Property Acquisitions

Acquiring developed property permanently eliminates risk and costs associated with flood damage prevention to at-risk structures. Acquisition allows for returning formerly developed lands to open space to support other beneficial uses, such as habitat, water quality, recreation, aesthetic enhancements, and interpretive sites and trails. Strategically implemented acquisitions support riparian and floodplain restoration, which enhances natural floodplain functions, provides opportunities to increase flood and sediment storage and conveyance, and supports the recovery of threatened and endangered species by restoring natural river processes. Acquisitions often involve purchase of an entire property, but partial acquisitions or easement purchases are also used in certain circumstances. In some cases, easements may allow for some continued flood-compatible use of the property, such as agriculture.

- King County has been acquiring flood-prone parcels from willing property owners for many years, through both fee acquisition and conservation easements. From 2013 to 2023, King County acquired 1,984 acres in the mapped 1 percent annual chance floodplain and an additional 83.5 acres in the 0.2 percent annual chance floodplain. Following the sale, structures are usually salvaged or demolished, some site restoration occurs, and the lands are maintained as open space in perpetuity. King County has also completed several significant acquisition efforts that removed many flood-prone structures from hazardous areas, which then facilitated large-scale floodplain reconnection. Examples include the San Souci neighborhood on the Tolt River and Rainbow Bend and Riverbend on the Cedar River. Several cities throughout King County also acquire flood-prone properties to reduce flood risk and provide land to enable restoration projects focused on enhancing habitat for threatened salmon.
- State and federal grants and some local funding sources are available to support the initial purchase and demolition of structures. Long-term maintenance and associated land management obligations typically remain with King County or the FCD, depending on custodianship.

Before (top) and after (bottom): Riverbend Manufactured Home Community on Cedar River before acquisitions (2009) and the same site after Riverbend Levee Setback and Floodplain Restoration project (2023)

Acquisition is a highly effective tool for flood risk reduction. It is not, however, without limitations and challenges:

- Ongoing monitoring and stewardship of publicly owned lands are necessary to prevent and address dumping, vandalism, and unauthorized encampments. Encampments result in people returning to flood hazard areas and reintroducing life safety risks that acquisition was meant to mitigate. Additionally, unauthorized encampments along rivers have the potential to damage flood protection facilities and riparian habitat through vegetation clearing and can impact water quality.
- The costs of acquiring developed property increase or decrease over time depending on local market conditions, and property owners can sometimes receive a higher price more quickly on the open market. This results in risk being transferred to new owners, who may be unaware of those risks.
- Acquisition can result in inequitable effects (Shi et al. 2022). The primary financial benefits of acquisition accrue to property owners. In cases where renters occupy acquired property, King County provides relocation assistance, but careful planning is needed to ensure acquisition does not fragment communities or result in displacement. These and other factors can result in socially vulnerable populations bearing a heavier burden from acquisitions (Shi et al. 2022).

Acquisition can reduce vulnerability by enabling at-risk community members to relocate to safer housing. Overcoming the potential for inequitable effects of acquisition requires equitable access to information about flood risks, acquisition opportunities, and potential relocation assistance. This information needs to be made available in multiple ways and using appropriate languages and communication methods for the given community.

King County rarely uses condemnation to acquire property. Condemnation involves using eminent domain when a mutually satisfactory negotiated settlement cannot be reached on a parcel essential to a project aimed at public benefit and is typically considered an acquisition activity of last resort.

Relocations

A relocation activity moves an at-risk structure to a new location outside the flood hazard area. The opportunity to relocate homes depends on such conditions as the desire of the occupants to keep their home, the availability of an appropriate new location for the structure, and the feasibility of moving the structure. King County does not typically make use of this tool, but it could be applied in certain settings.

Relocation projects can greatly reduce future flood damage while allowing property owners to remain in their homes and possibly on their property. Since a relocation project removes a home from a current flood hazard area, measures such as construction and maintenance of a flood protection facility, flood insurance, and emergency response services may no longer needed. Flood storage and conveyance can be improved, benefiting neighboring properties and public facilities. Relocations also create an opportunity to enhance or restore fish and wildlife habitat on the flood-prone portion of the property and, in some cases, provide public access to the shoreline. Like many home elevation projects, relocations could be incentivized to reduce flood risk, including through relocation assistance.

While beneficial, relocations still face some level of residual risk because of climate change. A relocation should only be considered a viable, long-term mitigation solution if the receiving site for the relocated structure is sufficient to accommodate potential shifts in the flood hazard area boundary that may result because of more substantial future flooding conditions. Additionally, relocation needs to consider other risks that may be introduced. For example, moving a structure away from the coastal high-hazard area could introduce landslide risk if the structure is not located appropriately.

Flood Insurance

While insurance itself does not mitigate risk, it is a tool available to help property owners and renters recover from flood damages. King County is currently a Class 2 community in the Community Rating System (CRS) because of its comprehensive and multifaceted floodplain management program. King County's CRS rating means property owners in unincorporated areas are eligible for a 40 percent discount on their flood insurance premiums. Some cities in King County also participate in CRS, but their discounts are lower than those offered in the unincorporated areas.

What King County heard

Community members strongly advocated for increased outreach to homeowners and renters on the benefits and availability of flood insurance. This was especially true for those more likely to identify as black, indigenous, or people of color or from immigrant communities.

Flood insurance is an additional policy on top of general homeowners' insurance. While many property owners may be required by their mortgage lender to acquire flood insurance, renters may not be aware of the flood risk of a property they are renting and need to be aware of their opportunity to insure their contents against flooding impacts.

Floodproofing

Floodproofing refers to structural or non-structural measures, changes, or adjustments that can reduce flood risk or flood damages. Two types of floodproofing are dry floodproofing and wet floodproofing. Dry floodproofing involves making all areas below the flood protection level watertight, whereas wet floodproofing lets water in and anything that could be damaged by a flood is removed or elevated above the base flood elevation.

Dry floodproofing has structural limitations, and with the exception of nonresidential structures and certain agricultural buildings, King County Code does not allow dry floodproofing as the only measure taken to demonstrate compliance with flood hazard area regulations. Wet floodproofing is typically an approach used in combination with home elevation projects, whereby the area below the base flood elevation must be constructed of flood-resistant materials, and the area cannot be used for habitation or contain appliances, utilities, or other elements that could be damaged by flooding.

As a mitigation tool, floodproofing is only appropriate in areas that experience slow moving or ponding floodwaters. Areas that experience fast flows or are subject to channel migration are not good candidates for floodproofing.

Sandbags

King County provides sand and sandbags to the public, free of charge, at several locations throughout the county in both incorporated and unincorporated areas. King County also advertises the locations of sandbag locations hosted by other King County communities.

3.3 Natural Resource Protection

Natural resource protection refers to activities that protect or restore natural areas and the natural functions and processes of river, floodplain, coastal, and watershed ecosystems. When allowed to function naturally, floodplains provide flood and sediment storage and flood conveyance benefits. Natural, fully functioning floodplains also provide valuable habitat for fish and wildlife, improve water quality, and are resilient to the effects of climate change.

In the Pacific Northwest, rivers, streams, coastal areas, and their floodplains provide habitat that is critical to the survival of Pacific salmonids, several species of which are listed on the ESA. King County has successfully collaborated with salmon recovery planning groups and other partners to implement floodplain reconnection projects that reduce flood risk to people and property while also dramatically improving habitat for salmon and providing other benefits. These projects clearly demonstrate that natural resource protection and restoration is an effective flood risk reduction activity.

What King County heard

Community members and partners strongly support working with nature to reduce flood risk. They view this as an important secondary benefit to consider in all flood reduction projects. Over 75 percent of community responses wanted to see protection of upper watershed areas and wetlands to store flood waters. More than 50 percent encouraged more projects to connect rivers to their historic floodplains as well as use green stormwater techniques to reduce stormwater runoff and flooding.

Individuals and partners from cities noted there can be financial and spatial challenges to implementing natural resource-based projects in urban areas. Some community members also requested renewed river dredging and raised concerns about beavers.

This section discusses the natural resource protection activities considered during the planning process. Examples of natural resource protection projects are illustrated in **Figure 3-1** and **Figure 3-2**.

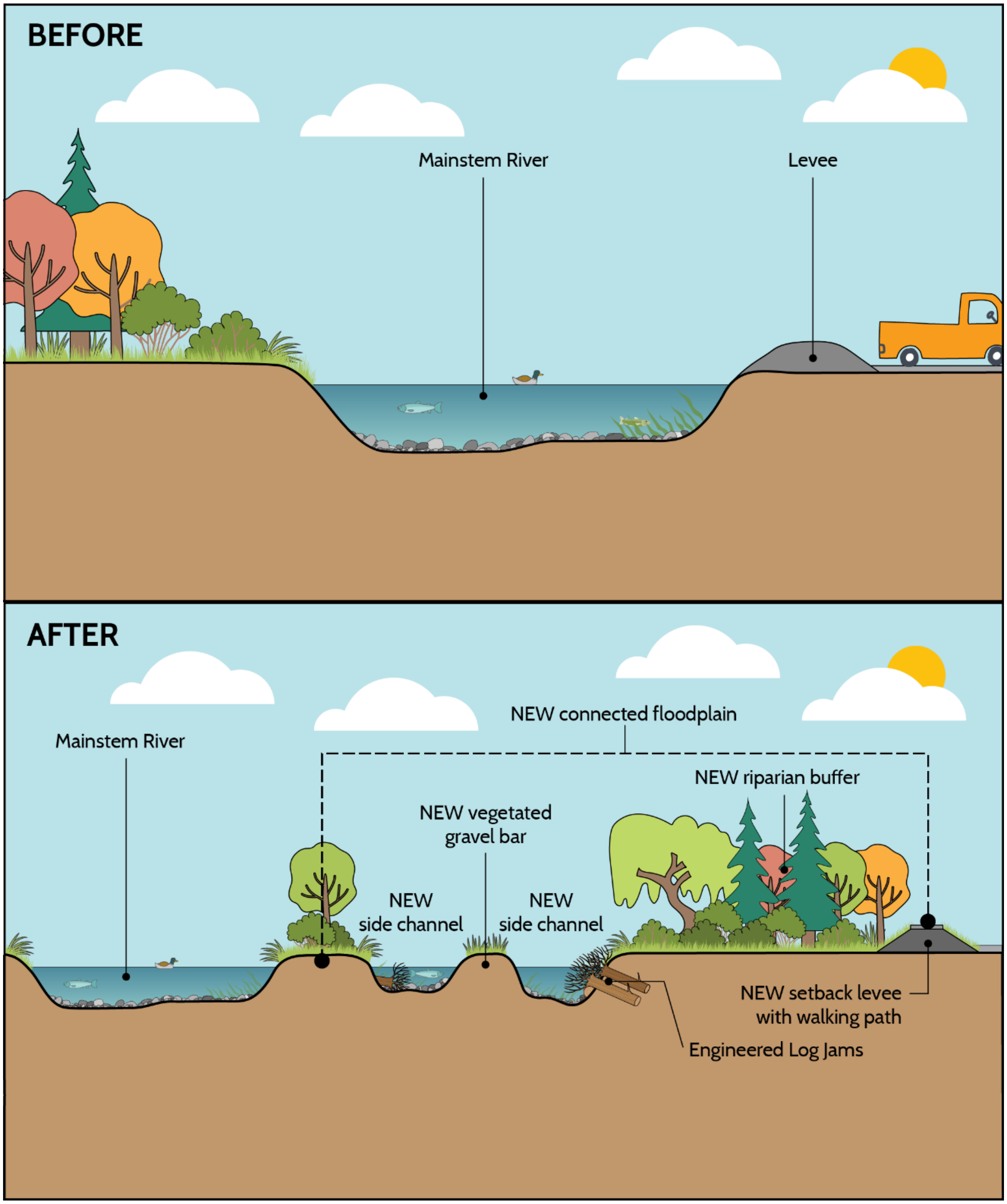


Figure 3-1
Example of a Natural Resource Protection Project (before and after)

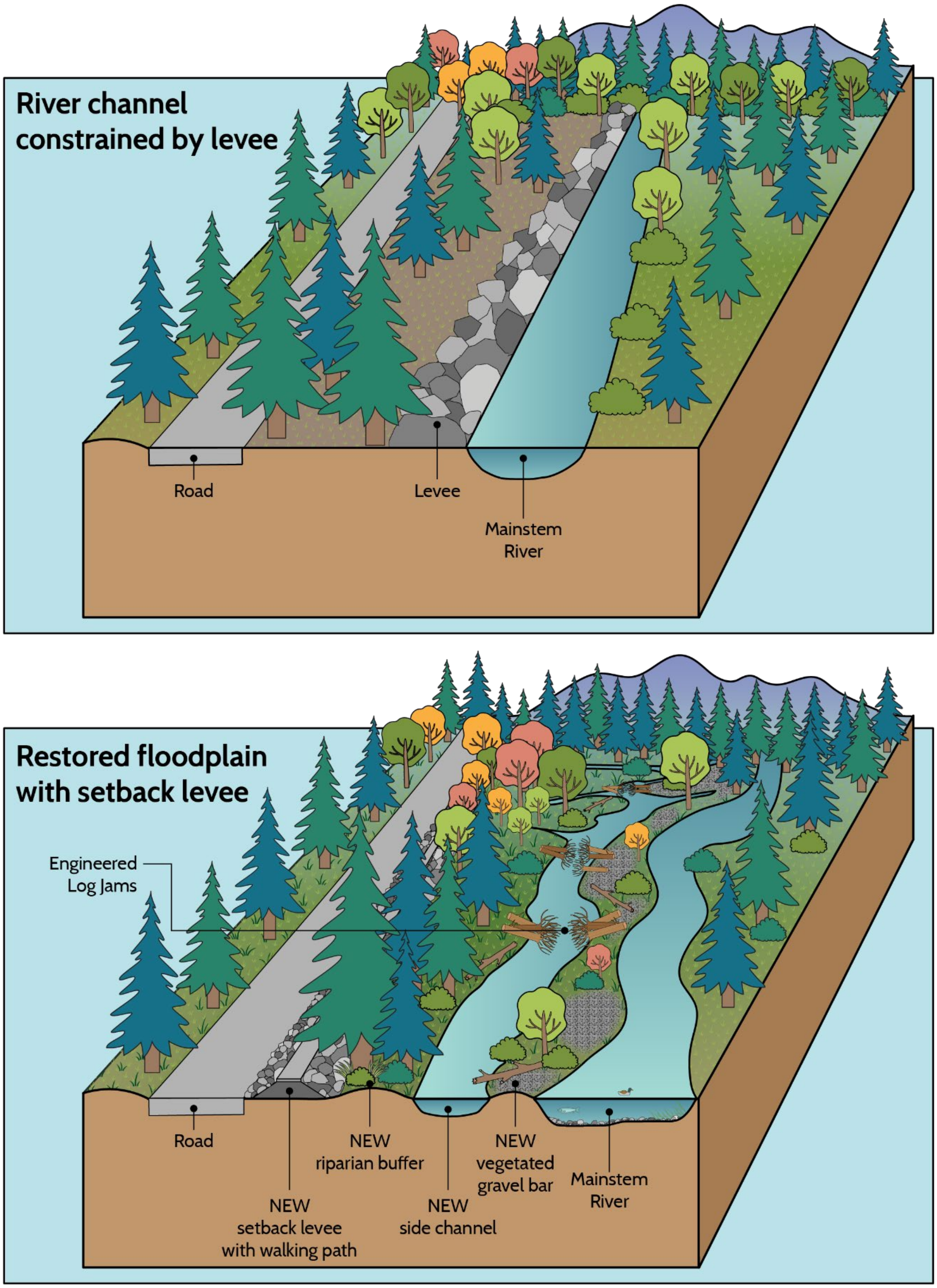


Figure 3-2
Example of a Natural Resource Protection Project, Setback Levee (before and after)

Floodplain Reconnection/Restoration Projects

The construction of levees and revetments and large-scale floodplain drainage networks in the 20th century along the rivers and streams of King County dramatically changed the nature of county rivers and floodplains. These structures allowed human development to proceed in areas that were previously subject to regular flooding. Disconnection of watercourses from their floodplains led to a substantial decrease in floodwater conveyance, storage, and habitat function. Furthermore, erosive water velocities increased due to the channelization of rivers and streams, resulting in repeated damage to many of the levees and revetments.

Reconnecting rivers and streams to their floodplains and restoring floodplain habitat is a way to allow nature to provide flood risk reduction benefits. Disconnected floodplains in King County vary in their current land use, from highly developed urban and industrial areas, to suburban and rural residential neighborhoods, to agricultural landscapes and open spaces. Reconnecting floodplains requires time and financial commitment, but the resulting projects can remove at-risk development from harm's way, provide natural flood attenuation and sediment storage, promote resilience to climate change, and dramatically improve fish and wildlife habitat.

Floodplain reconnection also allows for the reestablishment or creation of side channels and backwater channels in the floodplain. These channels enable river flow to reoccupy pre-existing or former secondary channels that were carved across the floodplain through years of historical flooding and channel migration. These floodplain remnant channels can be pathways to convey overbank flows and lower a river's flood elevations and velocities through a reach. Excavating new or connecting former floodplain channels can also provide additional flood water and sediment storage and geomorphic floodplain complexity. These types of off-channel features provide critical rearing and flood refuge habitat for juvenile salmonids and support habitat complexity that salmon need to survive.

King County has implemented several floodplain reconnection projects in recent years in each of the county's major watersheds, which have proven effective at reducing flood risk while also providing a host of other benefits to both the natural environment and local human communities. Notable examples include the Rainbow Bend and Riverbend projects on the Cedar River. These beneficial projects, however, can take 10 or more years to design and implement—longer for more complex projects with conflicting public interests. Grant funding is often needed to secure the resources needed, but relying on competitive funding for subsequent project phases can be problematic. Land acquisition can take decades for larger scale projects, especially those where many parcels are involved. Capital project sponsors' project timelines and funding distribution schedules do not always align with acquisition timelines.

Riverbend floodplain restoration and levee setback on Cedar River, January 2023

In many locations in King County, full floodplain reconnection and restoration is not possible due to current land use and development. In such cases, finding opportunities to restore as much function as possible can provide important and critically needed habitat function. Setting back a flood protection facility, such as a levee or revetment, even a short distance from the water's edge can increase slow-water edge habitat that is vital for juvenile salmon rearing and refuge (even though such projects can be very costly). Levee and revetment setbacks can also provide more cost-effective options for scour protection than more traditional structural methods and can reduce water surface elevations, meaning the setback facilities do not need to be built as high.

Large Wood Management

The presence of natural large wood in rivers and streams sustains ecological functions critical for salmonids and aquatic ecosystems, but the current amount of large wood in county waterways is greatly reduced from historical conditions. There is a well-documented need to substantially increase wood volumes in rivers and streams to support viable populations of salmonids. All WRIA-based salmon recovery plans addressing King County watersheds (one each for WRIAs 7, 8, 9, and 10) include goals to substantially increase the amount of large wood in rivers, methods that tribes, resource management, and regulatory agencies strongly prefer, and sometimes require, in river and stream projects.

In addition to natural wood, King County frequently uses large wood as a design element in flood risk reduction projects for bank stabilization and scour protection. While these wood features do not create and sustain salmonid habitat or restore river process as well as naturally occurring wood does, they provide habitat improvement over typical rock revetments by supporting the base of food webs and sometimes increasing habitat complexity. Wood elements are often required for mitigation as part of the permitting process, and Section 220-660-130 of the WAC[3] encourages and may require incorporating large wood materials in bank stabilization instead of rock.

In larger flood risk reduction projects, including floodplain reconnection projects, the use of large wood may also include anchored or unanchored large wood that is designed to influence natural river processes and reduce risk. For example, wood jams may be built to deflect flows and reduce erosion risk, and placed wood can influence patterns of sediment movement and storage. Natural floodplain processes in reconnected floodplain areas, including vegetation growth and wood recruitment from channel migration, also deliver natural wood to rivers and streams. In addition, these wood pieces have benefits beyond flood risk reduction via creating and sustaining habitat for fish and wildlife.

Safety concerns raised by recreational users, public safety officials, and project-specific risk analyses have resulted in procedures and policies for naturally occurring and placed wood in King County. For wood that is placed as part of a project, King County is required to follow the procedures outlined in a 2010 Public Rule that are intended to protect public safety (Public Rule LUD 12-1, effective April 30, 2010). The procedures include assessing potential recreational uses, identifying potential project impacts on public safety, accounting for public safety in project design, performing public outreach to allow for two-way communication with the public, monitoring and adaptively managing projects following completion, and reconvening partners and interested parties to re-evaluate large wood policies every 3 years.

For naturally occurring wood, King County developed procedures in 2013 to guide the King County Department of Natural Resources and Parks (DNRP) and the King County Sheriff's Office in responding to and assessing reports of potential public safety concerns associated with naturally occurring large wood in King County rivers, including whether the naturally occurring wood should be moved or removed in response. Recent King County experience with moving naturally occurring large wood for public safety concerns resulted in substantial mitigation costs required by fishery co-managers, for which there is no identified fund source. Given the continued decline of salmonids, the value of allowing natural wood recruitment and transport processes to function uninterrupted as called for in WRIA salmon recovery plans, and the likelihood of even higher mitigation costs for modifying naturally occurring wood, there is a need to reassess the large wood procedures to clarify the County's path forward as it relates to public safety.

3 https://app.leg.wa.gov/wac/default.aspx?cite=220-660-130.

Headwaters Protection

> **What King County heard**
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> Community members and partners expressed strong support for protection of headwaters areas, which can provide flood risk reduction benefits and other community benefits, such as clean water, fish and wildlife habitat protection and restoration, and recreational opportunities.

Many of the headwaters areas for King County's major rivers are already in public ownership, with some protected from development. For example, much of the Snoqualmie River basin headwaters are owned by the U.S. Forest Service (with some as designated wilderness). The upper Cedar River watershed is protected for municipal water supply by the City of Seattle. The Green River above Howard Hanson Dam is a patchwork of public ownership (City of Tacoma, U.S. Forest Service, Washington Department of Natural Resources). The upper White River is federally owned (Mount Rainier National Park and U.S. Forest Service), and 43,000 acres in the upper Green River watershed and portions of the upper White River east of the City of Enumclaw is protected by a conservation easement held by King County.

Even though the major river headwaters will not be developed in a way that introduces any direct flood risk, the management of these lands can influence flooding conditions downstream. While timber practices are less impactful on hydrology than the effects of impervious surfaces, timber harvest and road building can increase runoff and sediment delivery to the rivers that can affect areas downstream.

The headwaters areas of smaller tributary streams do not often have the same degree of public ownership, and the management of these areas can be influential to downstream risk. Protecting the headwaters areas of smaller streams presents an opportunity to promote infiltration and limit flashy runoff that is expected to become more common with climate change.

Wetlands Protection and Restoration

Similar to the protection of headwaters areas, wetlands protection provides natural flood risk reduction benefits. Wetlands store and infiltrate water and slow the flow of water downstream. They also provide important water quality benefits, promote aquifer recharge, and provide important habitat for fish and wildlife. While wetlands regulations are in place, some impacts are allowed if mitigated. Protecting and restoring wetlands, particularly those within the floodplain, may augment flood risk reduction actions. King County has implemented several riparian wetland restoration projects in recent years, and King County's In-Lieu Fee Mitigation Reserves Program provides funding for restoring or establishing wetland habitat when unavoidable wetland impacts occur elsewhere within the same watershed.

Beavers

Beavers are native to Washington state, and the dams they build store and infiltrate water and slow its movement through watersheds, which help reduce flooding and erosion. Beaver ponds provide habitat for fish and other aquatic species, improve water quality, keep water temperatures cool, recharge aquifers, and are a highly beneficial ecosystem component for salmon species.

> **What King County heard**
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> Localized flooding due to beaver activity was identified in numerous cities and unincorporated areas of King County. Suggestions for managing beaver-related flooding included increased monitoring of beaver activity and population size, temporary relocations, beaver dam management, and information for private property owners.

While beavers provide environmental and flood risk reduction benefits, they can also present challenges for human infrastructure that did not account for the animals' activities. In some cases, beaver ponds can back up water in locations that impact human land use, and beaver dam failures, especially above steep-slope hazards including above alluvial fans, can contribute to outburst flooding. King County has developed decision-support tools to aid in management of undesirable beaver activity, and the County partners with local nongovernmental organizations to provide technical assistance and resources for beaver management. More information is available on King County's website.[4]

Green Stormwater Infrastructure

Green stormwater infrastructure (GSI) refers to a variety of tools or stormwater facility types that are intended to collect, treat, and slow the flow of runoff in developed areas. GSI can take many forms, including bioswales and bioretention facilities (sometimes called engineered raingardens), pervious pavement, green roofs, trees, and even some storm ponds—all of which promote infiltration, improve water quality, control flows, and limit the adverse effects of stormwater runoff.

GSI is an effective tool when used at appropriate sites and scales. GSI is often used to retrofit existing stormwater management systems and is most effective when used in conjunction with gray stormwater infrastructure. Depending on the site, community, and regional scales where it is employed, GSI can be an effective addition to a catchment to reduce flows. Scaling these facilities up so that they manage larger volumes of stormwater will enhance their ability to provide meaningful flood risk reduction. Stormwater parks, although expensive, offer promise as a potential flood risk reduction solution at scale.

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[4] https://kingcounty.gov/en/legacy/services/environment/animals-and-plants/beavers.aspx.

Marine Shoreline Restoration

The marine shorelines of King County have been significantly altered from their natural condition, primarily through residential development and associated armoring with rock or concrete that is installed to protect landward development. While armoring can provide short-term erosion protection, it is subject to erosion and failure in the longer term and significantly reduces the ecological function of shorelines. Additionally, most of the marine shoreline armor was built to limit erosion and does not provide protection from high-water events. Of the 103 miles of marine shoreline in King County, 64 percent is armored and, for the urban shoreline, the armored figure is 84 percent.

King County's marine shorelines will face increased flood and flood-related risk in the future because of climate change and sea level rise (see *Coastal Flooding* in Section 2.6 for more detail). Restoring shorelines by removing armor and replacing it with natural elements is a way to improve ecological conditions and reduce the effects of coastal erosion, but restoring shorelines is difficult to implement due to the extent and type of shoreline development, which limit ideal settings for restoring shorelines appropriately. Moreover, reducing flood risk along the shoreline, especially in the future with sea level rise, will require development of more integrated and comprehensive solutions that include property protection measures (e.g., elevations, relocation, and acquisition) due to the proximity of many structures to the water's edge.

Before (top) and after (bottom): Maury Island Dockton Marine Shoreline Restoration, 2013–2022

3.4 Emergency Services

Emergency services include activities immediately before, during, and after a flooding emergency to minimize the impact. Activities considered include flood warning and response, critical facilities protection, and post-disaster mitigation activities.

Flood Warning Program

King County's Flood Warning Program collects and disseminates flood forecasts and alerts so that individuals and organizations can prepare for flooding and take appropriate actions to minimize flood damage. Currently, the Flood Warning Program provides services to both unincorporated and incorporated areas, primarily along the South Fork Skykomish, Snoqualmie, Tolt, Cedar, Green, and White rivers, and Issaquah Creek.

What King County heard

Uniformly, community input requested communication about flood evacuation routes and road closure information in real time, as well as improving coordination between government agencies during floods. There was also support for the need to accommodate vulnerable populations, especially people with low incomes and renters. Those who represented those communities asked for government agencies to build capacity of local organizations to respond effectively during floods. Some community members and partners noted that it can be unclear who is in charge and where they can find support during flood emergencies.

Flood warning activities are triggered whenever one or more rivers reach certain flow or stage (height) thresholds. The King County Flood Warning Center sends alerts to police, fire departments, schools, cities, first responders, and public subscribers through text messages, emails, and voice calls. Depending on the nature of the flood event, the Flood Warning Program may also deploy staff for on-the-ground assessment of flood protection facilities and investigation of potential flood risks. The Flood Warning Program works closely with King County's Road Services Division, the King County Office of Emergency Management, and other agencies to obtain and share up-to-date information about major flood risks, road closures, evacuations, and other emergency services. Coordination also occurs with the U.S. Army Corps of Engineers (Corps) and Seattle Public Utilities regarding dam operations and projected dam releases.

King County's designations of flood phases are primarily based on flows at specific gages, which means the information may be less useful depending on someone's location relative to that gage. A wide network of gages is available in King County, and the Flood Warning Program could look for ways to better connect to that network to provide information at a more useful scale for local decision-making.

There is a growing recognition that flooding occurs outside of the county's major river systems. Increasingly, smaller creeks and some coastal areas also face flood risk, but the types of predictive tools used for river flood warnings are not available for smaller stream systems or coastal areas. Because coastal flooding is driven by multiple factors—including wind-induced wave action, high tides, freshwater inflows, and elevated groundwater levels—the ability to predict coastal flooding is currently quite limited. Exploring ways to continue to reevaluate the services provided by the Flood Warning Program is an important step to ensuring the needs of all flood-prone residents in King County are provided information to help them prepare for potential flood risk.

Occasionally, the Flood Warning Center receives notification that a landslide has occurred, and landslide hazard potential generally increases with intense rainfall events that also cause flooding. King County Department of Local Services also receives landslide hazard reports that impact roads and structures. Better coordination and communication among King County departments and divisions and with external partners, including the Washington State Department of Natural Resources, is needed to improve timeliness of response to assess active landslide hazards and their impacts.

King County Flood Control District Flood Warning Center, November 2021

King County flood warning information is provided through multiple communication channels, and the communication methods used by King County change as behavior changes around accessing information. Near real-time river gage and flood phase data became available on King County flood warning websites in 2009. In that same year, the County introduced a flood alert system that allows people to subscribe for automated flood notifications via text message and email. A Flood Warning mobile app became available in

2012 on Apple and Android devices and is the most frequently used platform for individuals to obtain local river and flood data. The app will be replaced with a new version in 2024, which will include information in multiple languages. Additional flood warning communication methods include an interactive phone message system, blog posts, social media, and coordination with local media.

Emergency Response

When a given river reaches a certain flow threshold, the King County Office of Emergency Management activates the King County Regional Communications and Emergency Coordination Center. The center's role is to assist in procuring resources and coordinating flood-related and other emergency response activities in unincorporated King County and to assist cities and special-purpose districts within King County if resources are available. Response activities include coordination with other affected entities in the region, providing emergency updates using multiple methods, and evaluating the need for and activating emergency shelters as necessary.

What King County heard

Public comments indicated that most people don't know where to obtain information about emergency supplies, emergency plans, evacuation routes, road closures, locations of shelters, and early warning systems. This suggests that current outreach efforts have been inadequate to inform community members about the existence of these available resources.

Coordination in times of emergency is key to effectively serving the public, and many cities have their own emergency management programs. Feedback provided during the planning process for this Flood Plan suggests this type of coordination between local governments should be improved to serve communities more effectively in times of emergency.

King County deploys patrol teams to monitor river conditions during flood events. The primary emphasis for these patrols is to monitor levee system performance, but they also monitor conditions at other locations, sometimes in response to information received from citizens. Patrol teams are trained to recognize situations that warrant emergency action to preserve levee system function or otherwise reduce flood risk. Activities that King County may take or assist with to minimize flood damage include:

- Repairing damaged flood protection facilities that, because of the actual or potential consequences of their failure, must be restored as emergency actions before or during a flood event, or soon after floodwaters have receded.
- Providing information to flood response agencies engaged in flood-fighting and evacuations.
- Making flood-fighting information and flood-fighting materials available to individuals and groups actively involved in flood-fighting.
- Coordination with FEMA for flood disaster reimbursement and grants through the Public Assistance Program.

Currently, dam safety and emergency response plans are available for the City of Seattle's Tolt and Chester Morse (Cedar River) dams, the Corps' Howard Hanson (Green River) and Mud Mountain (White River) dams, and the Snohomish Public Utility District's Culmback Dam on the Sultan River, which is in Snohomish County and would affect the lower Snoqualmie River in a dam-breach scenario. Cascade Water Alliance has prepared an Emergency Operations Plan and conducts an annual emergency drill for the levee system on Lake Tapps, which would affect the White and Puyallup rivers if a levee failure occurred.

Factoring the effects of sea level rise into emergency response activities would expand emergency services to areas at risk. King County is currently partnering on a project to better understand the potential implications of sea level rise along the marine shorelines of King County, and the City of Seattle has analyzed its shoreline to identify areas at risk of inundation from sea level rise. This type of information could be used to develop emergency response measures that meet the needs of communities that may increasingly become vulnerable to coastal flooding.

Capacity for Community-Based Organizations to Respond to Emergencies

King County and cities within the county provide a range of emergency services to mitigate flood risk to people and property, but government is limited in its ability to help everyone, everywhere. For this reason, individual and local preparedness is key to building flood resilience. Local community groups and community-based organizations can play an important role in working with their networks to distribute information about flooding, the risks associated with flooding, and the variety of free or low-cost steps individuals can take to prepare for flooding and be ready in the case of an emergency. King County could make a concerted effort to build its capacity for emergency response with training, funded partnerships, and support, using specific knowledge learned from grassroots groups that serve the most vulnerable populations.

Technical Assistance to Property Owners and Renters for Short-Term Response Tools

Along with community capacity building to facilitate individual preparedness, King County and community groups can build individual and community resilience by helping individuals develop tools that can aid them during times of emergency. This can include making sure individuals are aware of their risk, understand where and how to obtain timely flood-related information, have a plan for what to do in times of a flooding emergency, and have appropriate emergency supplies on hand. Such technical assistance would be most effective if targeted on the most vulnerable and least resilient communities. It requires an understanding of cultural and language needs so that all communities are served effectively.

3.5 Structural Projects

> **What King County heard**
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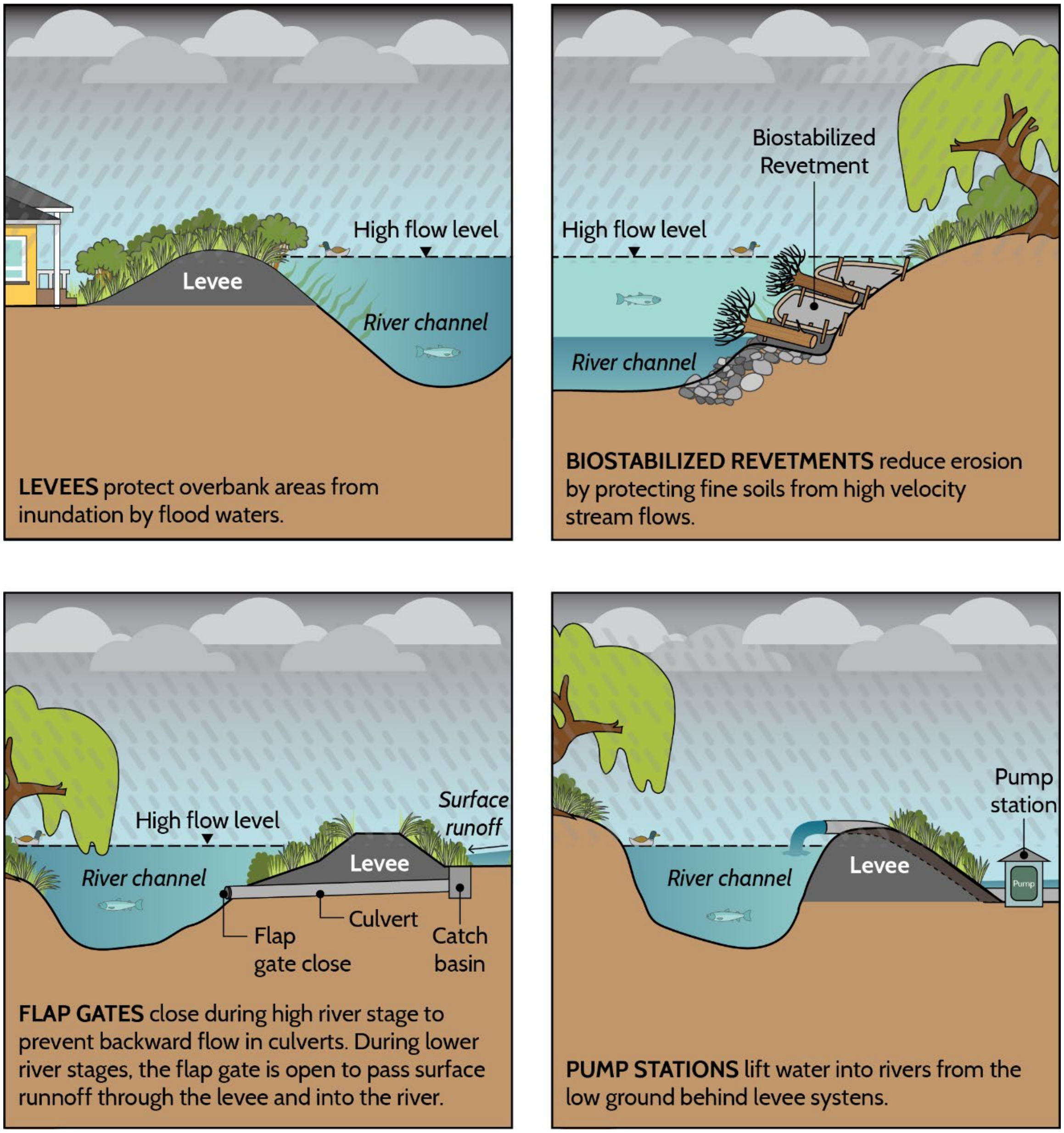
> Improving the flood resilience of roads and bridges throughout King County was identified as a priority, with specific mention of roads on Vashon-Maury Island, in Covington, and in May Valley. The most mentioned concerns for roads were in the Duvall and Carnation areas. There was a high demand for maintaining aging or damaged river protection facilities and considering adding new ones, including along the lower Duwamish River, as well as sharing more information about dams and dam failure planning.

Structural projects involve physical construction or maintenance of levees, floodwalls, revetments, pump stations, or otherwise physically modifying river channels and shorelines. Prior to 1993, flood risk reduction in King County relied heavily on constructed flood protection facilities to reduce and limit river flooding, erosion, and channel migration. Together, these levees, revetments, overbank channels, pump stations, and associated appurtenances paved the way for considerable economic development in flood hazard areas and floodplains.

Structural projects can be very effective in the short term in reducing localized flood risk, but the lifespan of the effectiveness is variable and considerable resources are required for maintenance and repairs. Additionally, some treatments may not perform as designed in the future due to climate change, yet overbuilt structural alternatives may result in undesirable ecological consequences. Areas protected by structural approaches face the potential risk that the facilities could be overtopped, resulting in serious flood damage or life safety risk. The presence of flood protection facilities can create a false sense of security among developers and property owners. Additionally, flood protection facilities in many locations have disconnected the river channel from adjacent floodplains, which has contributed to the greatly diminished quality and quantity of aquatic and riparian habitat that numerous species, including salmonids listed as threatened under the ESA, require for their survival.

King County has an extensive network of structural projects, many of which were originally built more than a half century ago, were sited without consideration of habitat impacts or equity and social justice implications, and which do not meet current design standards. Future management of the network will be most effective if management decisions are based on reach-scale or basin-scale risk-based assessments that identify the most appropriate activities considering long-term costs and benefits. These include compatibility with salmon recovery efforts and the land uses and vulnerability of the communities landward of the existing facilities.

Examples of structural projects are illustrated in **Figure 3-3**.



LEVEES protect overbank areas from inundation by flood waters.

BIOSTABILIZED REVETMENTS reduce erosion by protecting fine soils from high velocity stream flows.

FLAP GATES close during high river stage to prevent backward flow in culverts. During lower river stages, the flap gate is open to pass surface runnoff through the levee and into the river.

PUMP STATIONS lift water into rivers from the low ground behind levee systens.

Figure 3-3
Examples of Structural Projects

Levees and Floodwalls

Levees are raised embankments built parallel to rivers to contain floodwaters. Floodwalls serve the same purpose but are constructed of steel sheet piles and/or reinforced concrete. These structures were traditionally built immediately adjacent to the channel's edge, maximizing the landward area protected and available for developed uses.

In many locations in King County, substantial residential, commercial, and industrial development is protected by containment levee systems and, to a lesser degree, floodwalls. Of regional significance are the levees along the lower Green River, which provide protection to a regional economic hub, and those along the lower Cedar River, which provide protection to structures in downtown Renton, including a Boeing manufacturing facility and airport. Other containment levees are along the South Fork Snoqualmie River in North Bend, the Tolt River near Carnation, the Raging River near Fall City, and the South Fork Skykomish River in Skykomish. Levees along the lower White River near Pacific, while not intended to provide containment, protect residents and a city park from flooding and channel migration.

Levees are typically designed to achieve a certain level of protection, expressed either as a design containment flow rate in cfs or a return interval (e.g., protection from the 1 percent annual chance flood). The current level of protection provided by levees and floodwalls in King County varies by location, and structural flood protection will continue to be needed in places such as the lower Green and lower Cedar rivers, which calls for maintaining, repairing, and improving flood protection infrastructure.

Briscoe Levee construction on the Green River, September 2007

In 2014, the FCD (FCD2014-09.1[5]) adopted a provisional level of protection goal for portions of the lower Green River of 18,8000 cfs plus 3 feet of freeboard (equivalent to the 0.2 percent annual chance flood) for planned capital projects on the lower Green River. Levels of protection are also being considered elsewhere as the FCD develops Capital Investment

5 https://mkcclegisearch.kingcounty.gov/View.ashx?M=F&ID=3154469&GUID=E167E543-26C5-4A41-8C39-2AE1B1E712AF.

Strategies for specific rivers. In considering the levels of protection provided by the County's levees, the goals and policies of this plan should be considered, including consideration of alternatives that enhance resilience to flooding while also supporting climate resilient, equitable, multi-benefit outcomes.

King County has partnered with the Corps' Public Law (PL 84-99) Levee Rehabilitation and Inspection Program to receive federal funding assistance to repair levees damaged during flood events. The program also includes inspections and other assistance to prepare for and respond to floods and flood-related natural disasters. A number of repairs were carried out under this program between 2008 and 2016 on the Green River, and several repairs are planned for 2024 and 2025. Approximately 23.8 miles of levees in King County are currently enrolled in the PL 84-99 Program (in the Snoqualmie and Green River basins).

In the past, one of the most significant challenges associated with the PL 84-99 program was the rigid requirement related to vegetation management on levees and conflicts this presented with ESA salmon recovery efforts promoting riparian vegetation. In 2014, the Corps issued new interim guidance for levee inspections and PL 84-99 levee eligibility. Vegetation inspection ratings no longer factor into PL 84-99 eligibility determinations unless the presence of vegetation impedes inspection of the levee, and vegetation no longer disqualifies a levee from participation in the program, the effects of which provide greater latitude for local decision-making around maintenance practices. Periodically revisiting whether to participate in this program is a prudent measure in light of various pros and cons that accompany participation.

Levees can be accredited by FEMA. Accreditation is based on certification studies that the levee meets design and construction standards (for at least the 1 percent annual chance flood) and provide adequate risk reduction for NFIP mapping purposes. Areas landward of accredited levees are mapped as being protected by levees, and in these cases, flood insurance is not mandatory. However, risk remains for these locations, especially from levee failure due to breaching or overtopping. Such an event can produce devastating economic impacts due to people being uninsured or underinsured. Approximately 1,270 acres of land is currently classified as "Zone X - Protected by Levee" within King County.

Revetments

Revetments are flood protection facilities that are designed to deter or resist bank erosion and lateral migration of a river channel. Unlike levees, revetments are not designed to contain floodwaters, but rather to maintain the course of the river. Marine shoreline armoring, while not typically referred to as revetments, performs a similar function in that it is intended to resist erosion. Revetments and marine shoreline armoring may be built in locations that remain subject to flooding, or even in high bank areas where flooding is not an issue. Many of these types of features in King County protect roads, bridges, trails, parks, and other public infrastructure from being damaged or destroyed (such as the Dockton Road seawall on Vashon Island). Revetments also protect a substantial amount of private property and agricultural land from erosion and channel migration.

Revetment protecting Reinig Road on the Snoqualmie River, May 2023

Monitoring and Maintenance of Flood Protection Facilities

King County currently has an inventory of 511 flood protection facilities (levees, revetments, and a constructed channel, the Sammamish River), and the County, as a service provider to the FCD, updates information about the location and condition of facilities through regular inspections, post-flood damage assessments, development of capital investment strategies, capital project designs, modifications to facilities, and application of improved modeling and GIS location technology.

Many of King County's levees, revetments, and constructed channels were built in the mid-20th century, and some may no longer be needed. Land use changes and implementation of flood risk reduction activities are two reasons why an existing facility may not be needed today. In addition, some levees and revetments are relics from past management approaches and do not provide effective flood risk reduction consistent with the policies in the Flood Plan.

In locations where a levee or revetment has become obsolete, the removal of that structure may be useful to alleviate flooding risks upstream and downstream and to assist in restoration of river processes, natural floodplain functions, and, by extension, fish and wildlife habitat. Removal can be done on all or just a portion of a levee or revetment, and the activity requires careful consideration of all implications of taking this action.

Pump Stations

Pump stations help drain local runoff landward of a levee into a river, and they prevent river flows from backing up into protected floodplain areas when the river stage is high. These flood protection facilities function as appurtenances to the levee system. Any levee modification or repair must address these structures as well. Currently, King County operates three larger pump stations on the lower Green River.

Culverts

Culverts convey flow, and while they are not typically considered a structural flood control measure, they influence flood conditions when they are undersized and unable to convey high flows. Many culverts constructed decades ago are seeing much higher flows than in the past due to increased impervious surfaces upstream as well as changing precipitation patterns. Backwatering behind undersized culverts causes localized flooding of roads and property. While culverts can limit the amount of flow, they can also cause channel erosion downstream of the culverts. Culverts that pass-through levees may have flap gates, which prevent the backflow of river water through culverts in the levee and into the protected area.

What King County heard

During the planning process, there was a strong demand for improved drainage of stormwater to reduce flooding in urban, suburban, and rural communities. Stormwater infrastructure is viewed as inadequate for current and future heavy rainfall events. Increasing the size of culverts, daylighting streams, and replacing culverts with fish-passable structures were widely supported as solutions to stormwater and tributary flooding.

Proper operation of these systems is frequently impaired when they are blocked by sediment or debris. Issues also exist with culverts that transfer water from the landward side of the levee to the river, many of which are constructed with corrugated metal pipe that is prone to rust-induced failure. Other culverts are constructed with jointed segments of reinforced concrete pipe, which can separate at the joints as riverbank slopes settle differentially, leading to failure. Culvert outfalls may also cause erosion if outfall protection is inadequate.

In addition to concerns with their function, flap gates are a significant barrier to juvenile fish passage into and out of tributaries that are an important habitat type for high-flow refuge and for rearing as the fish make their way from freshwater to saltwater.

Replacing outdated, undersized culverts with bridges or box culverts can aid conveyance and improve fish passage. In Washington state, a federal court injunction is requiring state governments to replace culverts that block or restrict fish passage. Restoration of fish passage is a high priority for King County. The county's Fish Passage Restoration Program has assessed all the county culverts that limit fish passage and developed a prioritized work plan to replace barriers and allow streams to flow more naturally under roads and trails. Many cities are also replacing culverts to improve fish passage and alleviate local drainage issues.

Before (top) and after (bottom): Culvert replacement with fish-friendly box culvert on Ebright Creek under East Lake Sammamish Trail, 2022

Instream Flow Deflection Structures

Instream structures constructed of a combination of large wood and rock elements embedded, anchored, tethered, or placed in a river or stream channel are used to modify hydraulic conditions to deflect flows and reduce bank scour or erosion. Their presence in the channel forces flow around them and, depending on their placement, can create areas of scour (pools) or deposition (bars) that provide habitat diversity. King County has constructed numerous structures of this type to deflect flow away from particularly sensitive locations where a larger floodplain reconnection project is not possible.

Dredging and Gravel Removal

Removing sediment from river and stream systems to provide conveyance capacity through activities like dredging and bar scalping was, at one time, a fairly common practice in flood risk reduction. However, several monitoring programs, projects, and studies have provided significant data-driven information about channel response to gravel removal (King County 2021, 2019). Additionally, permitting, monitoring, and mitigation requirements of the gravel removal sediment management activity have made the practice considerably less feasible than before. Gravel removal provides limited and temporary flood risk reduction, has highly challenging permit requirements, and is detrimental to aquatic ecosystems and salmonid habitat.

At some locations in King County—such as the lower Cedar River—periodic maintenance dredging will be needed for navigation purposes for the foreseeable future. The lower 1.75 miles of the Cedar River is a federal flood reduction project constructed under Section 205 of the Flood Control Act of 1948. The Operations and Maintenance Plan for the Cedar River project specifies periodic dredging of the river channel within the project reach to provide conveyance for the 1 percent chance annual flood event. Maintenance dredging, however, is not a practice to be employed broadly throughout the county due to its significant limitations in terms of effectiveness, permitting complexity, cost, and harm to the environment.

Sedimentation Basins

Sedimentation basins are artificial depressions dug into areas designed to collect sediment so that the material is not transported downstream. These systems can be constructed in streams or adjacent to them and, regardless of the location, require periodic maintenance to make room for continuing sedimentation. Off-channel sedimentation basins that allow maintenance under dry conditions mimic the function of an alluvial fan and, if maintained properly, are less damaging to aquatic ecology than in-stream basins. King County currently operates several sedimentation basins.

Floodplains also provide natural storage of entrained river sediment. Floodplain reconnection projects that allow greater access by a river to its floodplain also provide locations for sediment (and large wood) storage. This sediment may be re-mobilized during flood events, which is an important process to aquatic habitat renewal, including fish spawning gravel.

Stormwater Management Projects

Stormwater management projects are implemented throughout King County to address the limitations of legacy infrastructure and to improve the capability of existing systems to manage increasing amounts of surface water runoff. All cities have their own stormwater/surface water management programs that guide the activities they implement and that seek to reduce stormwater impacts. King County has three programs to address rural stormwater flooding and rural drainage in unincorporated King County:

- **The Neighborhood Drainage Assistance Program (NDAP)** was created to address localized flooding, erosion, and sedimentation problems situated within the off-road drainage system. The program provides technical assistance to property owners impacted by runoff resulting from the cumulative effects of development where flows exceed the capacity of the stormwater system or where system maintenance is lacking. The program funds small-scale capital improvements to address flooding, erosion, and sedimentation problems affecting private property in unincorporated King County, including removing pipe blockages, replacing old infrastructure with new pipes and culverts, increasing the capacity of privately owned stormwater facilities, and removing sediment on alluvial fans. Funding for this program is relatively limited and allows completion of approximately two projects per year.
- **The Agricultural Drainage Assistance Program (ADAP)** provides technical assistance for the maintenance of waterways that are used to remove excess water from farm fields to allow for cultivation of agricultural lands in unincorporated King County. Although most ADAP projects are conducted on private lands to improve private drainage infrastructure, the ADAP may take on projects that improve conditions on public property.
- **The Natural Drainage Flooding (NDF) Program** addresses chronic drainage and flooding problems associated with streams, lakes, and wetlands. NDF projects address chronic drainage and flooding problems and are typically initiated based on drainage complaints that have been assessed with feasibility studies or were identified because of the urgency and severity of the problem. Projects may include constructing new stormwater facilities, removing sediment, controlling vegetation, and other work to improve drainage or otherwise reduce flooding outside of the built environment. Other potential actions include the purchase of flood-prone property, replacement or installation of culverts, or altering stream channels to increase the effective routing of sediment and stormwater in flood-prone areas.

The ADAP program provides effective flood risk reduction services to agricultural operations. The current NDF program is a functional and effective service for rural flooding problems in the natural environment on public lands in unincorporated King County.

Given the changes to the unincorporated area, the changes in the type and scope of drainage complaints received by NDAP, and more stringent stormwater management requirements, NDAP could be refined to focus on projects that maximize benefit to the County's stormwater system.

Outside of the limited scope of ADAP on agricultural areas, King County does not currently have a program that deals with smaller-scale flooding issues on private lands in the natural environment. Examples include properties adjacent to tributary streams, on alluvial fans in agricultural areas, and on other sites with low-density land use. To address this gap and to improve habitat on privately held natural lands, King County could create a new program to specifically address these flooding issues while focusing on the delivery of multiple benefits.

Flood Storage Projects

The impacts of flooding can be reduced by temporarily storing water behind dams or in stormwater flow control facilities. In these cases, floodwaters can be stored and then released or pumped out slowly at a rate that a river or stream can accommodate without causing flooding or reducing the magnitude of flooding.

Flood control dams typically have large reservoirs that are intended to protect downstream property from flood problems. Flow control facilities, such as detention ponds and retention ponds, are built to mitigate the impacts of smaller scale stormwater runoff. King County operates and maintains many stormwater flow control facilities. These facilities require ongoing maintenance to ensure their performance.

Two large dams in King County have the primary purpose of flood risk reduction: the Howard Hanson Dam on the Green River and the Mud Mountain Dam on the White River, both of which are operated by the Corps. The Howard Hanson Dam also stores a drinking water supply to the City of Tacoma and conservation flows within the Green River to enhance habitat. The South Fork Tolt Dam on the South Fork of the Tolt River, and the Chester Morse Dam on the Cedar River (both operated by the City of Seattle), do not have flood risk reduction as their primary purpose, but they can reduce flood peaks in certain circumstances.

3.6 Public Information

Public information activities include outreach, education, technical assistance, and other means of advising property owners, renters, and community members about flood hazards, the resources available to prepare for flooding, and the actions individuals can take to improve their resilience to flooding. Pro-equity public information approaches also include engaging community members in the decisions that will affect them, their communities, and their families.

Flood Hazard and Flood Preparedness Education

King County provides outreach and education to increase awareness of flood risks, help communities prepare for flooding, and prevent, minimize, and recover from flood damage. King County also shares opportunities to provide input into programmatic and capital project decisions that may impact communities and individuals and provides points of contact for members of the public to obtain flood-related information in large river systems. King County translates many of the informational materials it produces into at least one and sometimes more languages (other than English) and provides interpretation services upon request for in-person activities.

What King County heard

Continuing (and expanding) existing public education efforts about flood risk reduction and flood resilience was the most popular strategy in community feedback, with uniformly positive responses. Community members shared ideas about desired types of information types, intended audiences, and ways to reach people. Suggestions included youth-based education, offering disaster preparedness drills, and sharing information about flood risks to people buying or renting properties. This indicates that a multi-pronged, proactive approach to outreach and education is needed. Multiple community members noted the importance of providing translated, culturally appropriate materials to populations that need them.

The way people access information has changed dramatically since the 2006 and 2013 flood plans, and King County is interested in working with partners to evolve its flood preparedness program and improve the provision of these services to communities throughout the county. For example, King County has prioritized offering materials in different languages and using accessible language and concepts, yet even with those advances to better serve all communities, there are additional opportunities for improvement.

A holistic program for public information with increased, regular outreach aimed at building resilient communities is one approach. This effort could include attendance at local community events to raise awareness about flooding and available resources, and it could help build trust in government. This type of program could also streamline ways to keep communities informed about activities across King County, and community partners can serve as ambassadors and educators of resilience actions. Lastly, this type of holistic, integrated program would benefit from the establishment of goals that can be monitored and adaptively managed.

Many of the following activities have been implemented for several years and are funded by the FCD.

Annual letter to repetitive loss and flood-prone property owners: The letter makes property owners aware of the flood hazards likely to affect their property; highlights programs, resources, and projects available to help them reduce flood-related risks; describes steps they can take to protect themselves and reduce flood damage; and provides contact numbers for more information.

King County website: Hosts extensive information about flood preparedness and local flooding conditions, including:

- River conditions and flood phase information.
- Flood warning and emergency response information.
- The King County Flood Alert subscription service, which sends automated messages via text, email, or phone when rivers reach flood phases.
- Flood safety and preparedness videos in 21 languages.
- Floodplain and channel migration zone mapping.
- Flood Photo Viewer, a map-based application with aerial photos from previous significant flood events that illustrate the severity of flooding in inundation areas.
- Home buyout program and home elevation program information.
- A flood mapping application to assist in determining whether properties are within a 1 percent annual chance floodplain, a channel migration zone, or other hazard area.
- Flooding documents, such as the King County Flood Hazard Management Plan.
- Pages describing specific large capital projects and studies, as well as monitoring reports that share information about project effectiveness.

In addition to the links identified in the adopted 2006 Flood Plan, the website links to King County's online mapping resource, iMap[6]. iMap is a mapping application maintained by the King County Department of Permitting and Environmental Review that contains flood hazard information. Flood hazard map information is also accessible though the iMap website page.

Annual flood preparedness and flood response outreach: Each flood season, King County collaboratively refreshes messages to focus attention on preparation for flood hazards. The messages cover six priority topics: know your flood hazard, insure your property, protect people, protect property, build responsibly, and protect natural floodplain functions. Information on flood preparedness and response is shared before and during flood events through social media, the King County DNRP *Keeping King County Green* blog, the Office of Emergency Management's Trusted Partner Network, and articles in relevant partner newsletters. This educational campaign primarily focuses on generalized flood preparedness messages. County residents would benefit from a more diverse approach to address different types of communities, flood risk factors, and flooding types.

6 www.kingcounty.gov/iMap.

Flood preparedness brochures: Each year, King County assists the FCD in publishing and distributing a brochure with flood warning information. The brochure includes recommendations for flood insurance and personal preparedness, flood phases, important phone numbers, and websites. The brochures are mailed to approximately 29,000 households and businesses located within the floodplain. The brochure is translated in many different languages, and all are posted online and promoted through a news release as well as social media ads. To date, this brochure has focused on major river flooding.

Leveraging capital and programmatic communication: King County routinely communicates with community members to share information or gather comments about technical studies and capital projects, often via the county website or project-specific web-based engagement hubs. Often and as appropriate, education and information about flood hazards and flood insurance is included in communications to reach people in flood-prone areas. Communication methods include:

- Mailing postcards and letters to residential and commercial addresses.
- Outreach to develop topical or project-specific email or text notification lists.
- Holding virtual, hybrid, and in-person public meetings.
- In-person site visits.
- Project signage.
- Developing and maintaining project-specific, interactive web pages.
- Using targeted social media outreach.

King County has committed to communicating about changing and future flood conditions resulting from climate change in the context of individual projects.

A Program for Public Information (PPI) is a collaborative effort engaging a broad range of partners and floodplain managers to review local conditions and local public information needs and develop a strategic plan of activities. As it is a creditable activity under CRS, a PPI consists of the following parts, which are incorporated into this Flood Plan:

- The types of local flood hazards (coastal, riverine, dam inundation, etc.).
- The property protection measures appropriate for the flood hazard.
- Flood safety measures appropriate for the local situation.
- The public information activities currently being implemented within the community, including those being carried out by nongovernment organizations.
- Specific measurable goals for the public information program.
- The outreach projects that will be done each year to reach the goals.
- The process that will be followed to monitor and evaluate the projects.

Map Information Services

General information about flooding and risk reduction resources can be helpful to many people, but oftentimes property owners and renters need more guidance to better understand the options available for their specific situation. King County provides one-on-one consultation to property owners and renters looking to better understand their unique flood risk and to explain flood hazard area regulations, permitting requirements, flood insurance, and other types of technical assistance.

CHAPTER 4

Comprehensive Risk Mitigation Strategy and Action Plan

4.1 Overview

Chapter 2 of this Flood Plan documents flood and flood-related hazards and risks throughout King County, and Chapter 3 summarizes the different types of mitigation strategies and activities that were considered during the development of this plan. This chapter presents a countywide **Comprehensive Risk Mitigation Strategy**, which includes activities to mitigate flood-related risks in King County and that will help move toward the goals and objectives outlined in this Flood Plan. From the full Mitigation Strategy, the subset of activities that will be led and implemented by King County are identified. This subset of activities comprises the 5-Year **King County Action Plan.**

Developing the Comprehensive Risk Mitigation Strategy

The Comprehensive Risk Mitigation Strategy is based on actions identified by King County and those that emerged from more than 1,700 comments and conversations gathered in a variety of settings, as described in Appendix D, as well as by referencing publicly available information. In addition to direct requests for activity proposals, King County held a Partner Planning Committee workshop to discuss ideas for proposals.

King County evaluated each activity in the Comprehensive Risk Mitigation Strategy using criteria established in coordination with the Partner Planning Committee. Evaluation of activities was a qualitative process and did not require projects to meet a specific rating. However, all activities included must meet at least one goal of the Flood Plan (as identified in Chapter 1) and must not inherently conflict with King County's legal obligations.

The evaluation criteria included:

- **Flood Plan Goals –** The activity supports at least one of the Flood Plan goals from Chapter 1.
- **Legal Obligations –** The activity does not conflict with legal obligations of King County, including requirements under the Endangered Species Act (ESA), the Clean Water Act, and the National Flood Insurance Program (NFIP).
- **Policy Priorities –** The activity supports policy priorities from King County's strategic plans and other major initiatives related to climate, clean water, conservation, equity, and other topics.

- **Technical (Merit) –** The activity offers clear flood risk reduction benefits, is an effective approach to dealing with the identified problem, avoids negative community impacts, and supports resilience to climate change.
- **Technical (Durability of Benefit) –** The activity tends toward an approach that requires minimal maintenance needs over time.
- **Multiple Benefits –** The activity provides opportunity to realize one or more benefits in addition to flood risk reduction, such as habitat protection or restoration, productive agriculture, sustainable development, jobs and economic development, clean water, open space conservation, or recreation.
- **Financial –** The activity has funding secured, a funding strategy, or identification of additional funding that is still needed.
- **Timeline –** The activity can be completed, advanced, or initiated within 5 years.

The Comprehensive Risk Mitigation Strategy is divided into two parts: **programmatic activities** and **capital project activities**. Programmatic activities, in large measure, align with the flood risk reduction categories of prevention, property protection, emergency services, and public information. Capital project activities often involve projects focused on structural flood risk reduction or natural resource protection. The programmatic section of the Comprehensive Risk Mitigation Strategy is organized by activity type (which demonstrates how flood hazards are managed at a jurisdictional scale), while capital projects are organized by watershed (which demonstrates how flood hazards are managed at site scales or across specific landscapes).

Functions of the Comprehensive Risk Mitigation Strategy

During the planning process, partners stressed that the Flood Plan should include activities that would be led or implemented by entities other than King County. The Comprehensive Risk Mitigation Strategy helps establish a shared understanding for the breadth of work that needs to take place to build flood resilience countywide. The source or origin is identified for each activity, as well as the potential funding sources that may be used for implementation. Activities listed for the Comprehensive Risk Mitigation Strategy do not constitute an obligation for any of the identified potential implementation partners to fund or implement the activity. This remains King County's plan for flood resilience and flood risk reduction; King County does not have the authority to direct the work of others, including the King County Flood Control District (FCD). The activities listed on the Comprehensive Risk Mitigation Strategy were either submitted voluntarily by the lead agency, identified through partner feedback during the Flood Plan process, or obtained using publicly available information.

King County Action Plan

An important component of the Comprehensive Risk Mitigation Strategy is the subset of activities where a King County department is the lead agency and is committed to implementing or advancing the action. These activities comprise King County's Action Plan, consistent with Step 8 of FEMA's CRS planning framework. While the Action Plan is nested within the Comprehensive Risk Mitigation Strategy, it is also reflected in this chapter as a stand-alone section.

4.2 Focus Areas of the Comprehensive Risk Mitigation Strategy

The 2024 King County Flood Plan includes flood hazard topics that were not included in past flood plans and expands upon established topics that have become increasingly more relevant. The expanded scope includes climate change resilience, flood hazard solutions that provide multiple benefits, equity and social justice, and flooding from all sources. These themes were a focus throughout the development of the Flood Plan, with input from King County staff, members of the public, and government partners informing how these themes are incorporated into the plan and addressed through flood risk reduction activities.

Sources of Flooding

For capital project recommendations, past King County Flood Plans primarily focused on riverine flood hazards and major tributaries. However, flooding occurs in many other environments. Changes in development and climate since the 2006 Flood Plan have influenced flooding characteristics, which requires interventions in areas that have not historically been the focus of King County's flood hazard management efforts. The 2024 Flood Plan aims to address all predominant forms of flooding throughout the county. To effectively address all forms of flooding, King County solicited input from a wide range of audiences on various types of flood risks. This is shared throughout this Flood Plan and also in Appendix D. The following sections outline how the different flooding types are represented in the Comprehensive Risk Mitigation Strategy.

Riverine Flooding

Riverine flooding continues to be a strong focus of King County's flood risk reduction program. Community and partner engagement included many discussions of riverine flood risks, many of which King County and partners have been working to address through ongoing efforts. While many riverine flood risks are rather well understood, climate change is causing risks to evolve, and much more work remains to deliver multiple benefits that improve the resilience of county communities and ecosystems. This Flood Plan continues the focus on many different types of programmatic efforts and capital projects to address riverine flood risk.

Activities that address riverine flooding are identified in the Comprehensive Risk Mitigation Strategy with the icon shown at the left.

Coastal Flooding

Previous King County flood plans had limited consideration of coastal flood risks and risk reduction activities. The 2024 Flood Plan set out with the intention of addressing coastal flooding and obtained external input to identify needs and opportunities for reducing coastal flood risks. In discussing mitigation options for at-risk coastal properties, partners revealed many challenges, and based on the input provided, King County intends to further assess coastal flooding and the impacts of climate change on coastal landscapes to determine services to provide related to emergency response, property protection, capital projects, and regulations. In particular, King County will look to other states and coastal communities to assess coastal flood resilience efforts and consider how successful interventions used elsewhere might work locally.

Activities that address coastal flooding are identified in the Comprehensive Risk Mitigation Strategy with the icon shown at the left.

Tributary Flooding

King County will prioritize preventive, natural resources protection, structural, and public information activities to reduce flood risks associated with tributaries. King County will increase monitoring and mapping efforts to better understand hazards related to sediment accumulation, including identification and mapping of alluvial fan hazard areas. The County will also undertake many conveyance capacity projects in areas with known conveyance issues to remove restrictive culverts that result in sediment and debris accumulation, excessive erosion, back-up during high streamflow events, and prevent fish passage. For more site-specific tributary flood risk reduction, King County will also provide technical assistance programs for addressing flooding on private property and agricultural lands as well as continuing to provide resources and assistance related to beavers.

Activities that address tributary flooding are identified in the Comprehensive Risk Mitigation Strategy with the icon shown at the left.

Urban Flooding

King County will use input on urban flooding to inform its Stormwater Services programs, including system maintenance, stormwater education, property owner support, emergency response, and capital programs. Recognizing the lack of data on urban flood risks due to stormwater runoff, the County will undertake efforts to better define these data gaps and identify efforts that can help to bridge these gaps and better inform stormwater management efforts.

The Flood Plan emphasizes a watershed-scale approach to flood hazard management. Protection and restoration of upland areas and wetlands will be a high priority to mitigate runoff and reduce flooding downstream. King County lacks jurisdiction in many urban areas within the county that experience stormwater flooding, but the County has a history of mutually beneficial collaborations with other jurisdictions in flood risk reduction efforts and will look to build on these in the future.

Activities that address urban flooding are identified in the Comprehensive Risk Mitigation Strategy with the icon shown at the left.

Key Themes of the Flood Plan

King County developed the 2024 Flood Plan with key themes of equity and social justice, climate change, and multi-benefit flood risk reduction at the forefront. These themes have guided the development of a Flood Plan that, when implemented, will provide long-term benefits that support diverse interests and communities. The following subsections summarize how these themes informed the development of the Comprehensive Risk Mitigation Strategy.

Climate Change

The planning process considered the ways climate change could influence flood and erosion risk, including increased risk arising from extreme precipitation events, changing snowfall patterns, and sea level rise. Incorporating climate change considerations into the Flood Plan will help build a stronger understanding of potential future risks and increase resilience to future flooding and other hazards.

Climate change resilience was a major factor in considering activities to include and prioritize in the Comprehensive Risk Mitigation Strategy. King County's actions across all fields of work are guided by the County's Strategic Climate Action Plan, including planning, design, and programmatic efforts related to flood risk reduction. King County will implement a significant number of projects to improve the capacity of culverts to accommodate increased precipitation volumes due to climate change, which are already overwhelming existing stormwater infrastructure.

Modeling efforts to better understand localized climate impacts will also be a key effort undertaken by the County, with a major coastal vulnerability assessment planned for Vashon-Maury Island. An adaptive management approach will be used to implement the Flood Plan, which will accommodate changes in flood risk reduction activities that may be necessitated by new climate change information or impacts. This approach will support a responsive climate resilience effort from the County.

Equity and Social Justice

The impacts of flooding often fall heaviest on historically underserved populations, who are more vulnerable to these impacts. A key consideration in the development of the Flood Plan was the identification of inequities in flood impacts and the means of reducing the burden on communities that have faced historic injustices.

Equity and social justice were key considerations in the evaluation and final selection of activities in the Comprehensive Risk Mitigation Strategy. Work performed by King County is guided by the policies and strategies outlined in its Equity and Social Justice Strategic Plan, with the prioritization of flood risk reduction activities informed by how they may support those policies, among other county initiatives.

In addition to equity and social justice being a key consideration throughout various flood risk reduction activities, King County is advancing efforts in all areas, with an emphasis on public information, technical assistance, and emergency services to address inequities. These efforts include working directly with communities most vulnerable to future flood risks and those that have faced harm in the past to raise awareness of flooding and improve understanding of the risks faced by vulnerable communities. King County also intends to explore how it can increase its work with community organizations to co-create and implement informational campaigns that will build community capacity to increase flood resilience and will identify ways to track and measure progress in this effort.

Multiple Benefits

The provision of multiple benefits by flood risk reduction activities was a key evaluation criterion when reviewing activities for the Comprehensive Risk Mitigation Strategy. Many of the additional benefits provided by flood risk reduction activities—especially benefits that can be provided by capital projects—are priorities for other King County initiatives related to habitat, agriculture, open space, climate change, and equity.

Floodplain reconnection or other natural resource protection and restoration activities, along with conveyance improvement projects, account for many King County activities that will address flood risk and provide other benefits. Through these and similar projects led by other partners in the Comprehensive Risk Mitigation Strategy, the Flood Plan aims to support the identification of opportunities for collaboration on mutually beneficial activities that could increase the potential for multi-benefit flood risk reduction projects.

4.3 High-Priority Activities

This Flood Plan does not include a comprehensive prioritization of activities in the Comprehensive Risk Mitigation Strategy because the strategy includes a range of activities that various entities in the county may undertake based on their own internal priorities. King County's own priorities are reflected in the King County Action Plan in this chapter. However, based on input received from partners and from the public throughout the planning process, the following activities and types of activities have been identified as being high-priority to address flood hazards in the county:

- Implementing the FCD's Capital Improvement Plan and Capital Investment Strategies, which reflect a range of capital projects that address flood hazards throughout the county, including in priority areas identified by partners and community members, such as the Snoqualmie Valley Agricultural Production District and Lake Sammamish.

- Implementing the multi-benefit framework described in Chapter 5 of this Flood Plan to ensure that capital projects moving forward are designed collaboratively and with a range of benefits beyond flood hazard reduction in mind and strategically implemented in coordinated fashion.
- Identifying and implementing activities to reduce coastal flooding risks throughout the county.
- Implementing equity-focused actions, such as the Equity Performance Measures and Monitoring programmatic action included in the King County Action Plan and continuing to incorporate equity into implementation of all activities.
- Implementing an enhanced program of public information around flooding issues, including increased outreach to historically underserved communities.
- Increasing emergency response coordination between jurisdictions and departments and taking action to empower community groups to support flood response and recovery activities.
- Implementing climate resilient activities to reduce the risk of flood and erosion damage to roads and other critical transportation infrastructure and maintain ingress and egress during times of flooding.
- Protecting undeveloped floodplain areas and preventing new development that interferes with natural floodplain function and puts people and structures in harm's way.
- Developing and implementing actions to reduce risks and damages from king tide- and sea level rise-related flooding in tidally influenced areas of the Duwamish River, including the South Park neighborhood.

4.4 Comprehensive Risk Mitigation Strategy–Programmatic Recommendations

The programmatic recommendations of the Comprehensive Risk Mitigation Strategy reflect the wide array of services, planning efforts, regulations, and day-to-day operations of the many governments and organizations involved in flood risk reduction in King County. Programmatic recommendations are organized by activity type because these categories often serve different goals and functions of flood risk reduction. As such, the organization of this section provides a cohesive narrative that outlines the types of flood risks identified in the planning process and how those risks are being addressed. The activity categories include preventive, property protection, natural resources, emergency services, programs supporting structural activities, and public information, all of which are divided into subcategories.

Key for the Icons Used in the Comprehensive Risk Mitigation Strategy and the Action Plan

Flooding Type	Icon	Timeline	Icon
River		Ongoing	
Tributary		1–5 years	
Coastal		5–10 years	
Urban		>10 years	

Preventive Actions

What King County heard	How this informs King County's approach in the 2024 Flood Plan
Community members and partners described preventive activities as important measures for adapting to the changing landscape and climate and how these factors affect flooding. Community input, especially among immigrant farmers and historically underserved groups, indicated that incentives or technical support to develop in low-risk areas were extremely important preventive actions. There was also widespread support for the adoption and enforcement of stricter regulations to limit development to reduce the risk of future flooding. Input also pointed to the potential for mapping and modeling to identify how these changes affect flooding, especially regarding coastal, urban, and tributary flooding. Mapping and modeling that account for changing conditions and identify floodplains in previously unmapped flood hazard areas were discussed as useful tools for developing land use regulations that address these types of flooding. Suggestions to address stormwater runoff that floods tributaries and urban areas garnered many suggestions for mitigation, including retrofits, green stormwater infrastructure (GSI), stricter land use regulations, and open space and wetland protection.	King County will continue to study flood hazards to ensure that its flood risk reduction strategies are informed by the most current conditions and best available science for future projections. These studies serve as the geographic basis of existing floodplain development regulations and may inform potential future regulations, such as regulating land use in alluvial hazard areas or projected future flood hazard areas. King County will collaborate with other jurisdictions and partners to identify hazards that could be addressed with improved upper watershed storage or infiltration, increased conveyance capacity, or stricter land use regulation in hazard areas. King County will work to incorporate multiple benefits into these activities, such as habitat protection or enhancement, recreational access, protected open space, agricultural production, and safe transportation. Activities under Preventive Actions are presented for Flood Hazard Mapping, Land Use and Regulations, Monitoring and Maintenance, Open Space Conservation, and Stormwater Management.

Flood Hazard Mapping, Assessments, and Planning

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Landslide Hazard Mapping — Expand understanding of landslide risk areas through updating maps as information changes and tracking recent landslide events and use this information to inform the development of appropriate mitigation solutions where coastal, tributary and riverine flood hazards and landslide hazards intersect.		King County	
Continue to **develop, revise, and update flood and channel migration hazard area mapping** as needed and to reflect changing conditions, including incorporating updated information about the potential effects of climate change on flooding conditions. [The status of floodplain and channel migration mapping efforts is provided in Appendix I.]		King County FCD	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Topographic and Ortho Imagery Data Collection — Routine repeated data collection of high-resolution blue-green Light Detection and Ranging (LiDAR) and orthographic aerial photography for use in hazard mapping, monitoring, and capital project planning.		King County FCD	
Levee Breach Analysis — Conduct mapping and risk assessment of five levee containment systems in King County (the lower Raging, lower Tolt, South Fork Snoqualmie, South Fork Skykomish, and Cedar rivers) to evaluate vulnerability to breaching, evaluate potential impacts, and make recommendations for structural and emergency actions.		King County FCD	
Analyze and map alluvial fan hazard areas.		King County	
Coastal Flooding Best Practices — Evaluate best practices from other states for coastal flood mitigation and identify options that could be applied locally.		King County	
Comprehensive Residential Mitigation Feasibility Study — Update and expand the County's Repetitive Loss Area Analysis to conduct a study of all unincorporated areas to assess flood vulnerability of residential structures and recommend mitigation actions.		King County	
Lake Sammamish Flood Forecast Model — Develop a flood forecast model for Lake Sammamish to help residents prepare for high lake levels.		King County or King County FCD	
Snoqualmie Valley Major Flood Mitigation Study — Determine which major roadway(s) that cross the Snoqualmie Valley would be the most cost-effective to improve in the valley with chronic flood issues that have the potential to impact more than 25,000 daily drivers. Roadways to be studied include NE 124th Street, NE Woodinville-Duvall Road, Tolt Hill Road, and NE Carnation Farm Road.		King County FCD	
Lower Green River Corridor Plan and EIS — Provide planning services and technical support related to the environmental impact statement and flood hazard management plan.		King County FCD	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Lower Snoqualmie Valley Compensatory Storage Study — Conduct a study to identify compensatory storage capacity within a limited valley to guide decisions around development, including agricultural flood refuge, residential structures, maintenance of transportation corridors, etc.		King County FCD	
East Fork and Mainstem Issaquah Creek Stream Evaluation — Conduct a study to evaluate options for addressing stream flooding and bank erosion due to downed trees and channel migration.		City of Issaquah	
Kimball Creek Riparian Improvement Study — Identify opportunities for ecological health improvements to Kimball Creek riparian areas. Evaluate existence of unnecessary levees or revetments, non-native weed infestations, and possible stormwater improvements.		City of Snoqualmie	
Update Lake Sammamish Flood Study — Addresses problematic mapping of homes in and out of the floodplain due to poor-quality elevation data. New high-resolution aerial photos and LiDAR data collected in 2020 and 2021 could produce significantly more accurate mapping.		King County	
Use projections of changes in future river flows **to study potential changes in river or basin-scale risks from climate change** in order to inform appropriate risk reduction and resilience actions.		King County	
Develop Snoqualmie Valley Integrated Resilient Watershed Plan —Develop a watershed-based plan for the Snoqualmie Valley that looks at the unique values and issues in the basin, including a risk assessment, structural and non-structural protection alternatives, beaver management, management of headwaters and forestlands, riparian and shoreline management, compensatory storage, water availability, climate impacts, sediment and erosion, and emergency preparedness. Identify priorities and establish an implementation funding strategy.		Snoqualmie Valley Watershed Improvement District	(or undetermined)
Flood and Erosion Risk of multi-benefit actions in the upper Snoqualmie River — Conduct a flood and erosion risk analysis that includes proposed climate change and river resiliency actions.		Snoqualmie Tribe	(or undetermined)
Upper Snoqualmie Confluence Assessment — Conduct assessment of river and floodplain crossings within the confluence reach to evaluate their impact on river and floodplain processes. This assessment should include two bridges over the Middle Fork & North Fork Snoqualmie River as well as any floodplain overflow channels and wetlands. A potential outcome of the assessment could be proposing to improve the existing bridges. Develop alternatives for restoration and preferred restoration alternative (if any).		Snoqualmie Tribe	(or undetermined)

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Develop Snoqualmie Valley Integrated Resilient Watershed Plan —Develop a watershed-based plan for the Snoqualmie Valley that looks at the unique values and issues in the basin, including a risk assessment, structural and non-structural protection alternatives, beaver management, management of headwaters and forestlands, riparian and shoreline management, compensatory storage, water availability, climate impacts, sediment and erosion, and emergency preparedness. Identify priorities and establish an implementation funding strategy.		Snoqualmie Valley Watershed Improvement District	 (or undetermined)
Analysis of Farmland Erosion in the Snoqualmie Valley — Improve understanding of the extent of farmland erosion and the existence of revetments, regardless of ownership, and evaluate and prioritize options to address farmland erosion while considering tradeoffs among farm, fish, and flood objectives.		Snoqualmie Valley Watershed Improvement District Snoqualmie Valley Preservation Alliance	 (or undetermined)
Snoqualmie Valley Flood Risk Reduction Feasibility Study — The feasibility study is intended to help understand the effectiveness of different options for reducing the peak of fall and spring flooding and how likely it is that the options could be implemented.		Snoqualmie Valley Preservation Alliance Snoqualmie Valley Watershed Improvement District	 (or undetermined)
Pluvial Flood Modeling — Identify modeling needs and priorities to better understand risks associated with pluvial flooding.		Identified during public process	 (or undetermined)
Urban Flooding Climate Change Models — Develop models to show the increased frequency of flash flooding and sheet flow in urban areas resulting from climate change.		Identified during public process	 (or undetermined)

Land Use and Regulations

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Collaborate with jurisdictions to identify differences in municipal flood hazard area regulations within King County, identify implications for achieving plan outcomes, and provide technical assistance to jurisdictions within King County to support strengthening local regulations where they are deemed beneficial.		King County	
Develop alluvial fan hazard regulations.		King County	
Update King County's Flood Hazard Code to ensure continued protection of life and safety, FEMA compliance, and continued exceedance of NFIP minimum standards while also recognizing the value of flood hazard areas as critical habitat for ESA-listed species and allowing for efficient and effective restoration of natural floodplain functions and culvert replacement to restore fish passage.		King County	
Evaluate opportunities for regulatory flexibility for flood resilience upgrades to structures that do not conflict with the County's NFIP standing.		King County	
Provide Accessible Customer Support Information — King County's exemplary floodplain regulations are complex, and permitting delays or errors can be caused by customers not understanding the purpose behind the code or permit and submittal requirements.		King County	

Monitoring and Maintenance

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Channel Monitoring and Sediment Management Program — Continue to conduct channel monitoring using survey and blue-green LiDAR data of the Middle and South Forks Snoqualmie, lower Snoqualmie, Raging, Tolt, White, and Cedar river channels as part of King County's Sediment Management Program.		King County FCD	
Implement River Site Management Program (SMP) – Continue to conduct routine maintenance including mowing, vegetation management, and deficiency maintenance for river facilities and sites. Develop and update site management plans as needed.		King County FCD	
River Facility Inspection Program — Conduct annual inspections of levees and revetments to identify maintenance or repair needs.		King County FCD	
Effectiveness Monitoring — Monitor projects and land management activities to evaluate performance, meet permit requirements, and provide information for the design and construction of future capital projects and long-term land management operations. Monitoring varies by project and may include assessment of project structures, flood performance, plantings, channel morphology, and fish and wildlife habitats.		King County FCD, King County	
Equity Performance Measures and Monitoring — Develop performance measures for floodplain management equity outcomes and incorporate them into King County monitoring activities.		King County	
Update *Sammamish River Flood Control Project Operations and Maintenance Manual* — Work in coordination with the U.S. Army Corps of Engineers to update agreement for maintaining the Sammamish River Flood Control Project.		King County FCD	

Open Space Conservation

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Protect headwaters of tributary streams that may be sensitive to climate change to alleviate flashy flows and mitigate downstream flood risk.		King County	
Land Conservation Acquisitions — Acquire open space for conservation and protection, and secure footprints necessary for floodplain and tributary restoration projects and stormwater retrofit projects.		King County	

Stormwater Management and Maintenance

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Pursue opportunities to support **stormwater retrofit projects** as part of scoping and designing flood risk reduction projects in unincorporated King County.		King County	
Drainage Enforcement Program — Enforce the requirements of the *King County Surface Water Design Manual*, including the attenuation of runoff from developed surfaces that would otherwise increase flood flows.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Road Drainage System Preventive Maintenance — Perform annual catch-basin inspection and cleaning to ensure drainage systems remain unclogged and functional. This activity also includes cleaning drainage ditches, mowing, and litter and debris removal.		King County	
Neighborhood Drainage Assistance Program (NDAP) — Resolve stormwater-related flooding, erosion, and sedimentation problems in unincorporated King County by designing, building, or repairing drainage systems or providing technical assistance, with a focus on projects that maximize benefit to the County's stormwater system.		King County	
Road Drainage System Reactive Maintenance — Resolve stream, ditch, or drainage system clogs within the road right-of-way without increasing fill in the floodplain or causing a rise in base flood elevations.		King County	
Road Drainage Preservation Program — This program identifies, prioritizes, and improves roadway drainage infrastructure related to surface water, groundwater, and stormwater runoff. Improvements aim to reduce flooding and mitigate property damage.		King County	
Green Stormwater Infrastructure (GSI) in Urban Villages Program — Construct bioretention facilities in urban villages to improve conveyance, address surface flooding, and mitigate risks to the drainage and wastewater system.		Seattle Public Utilities	
Seattle Public Utilities Spot Drainage Program — Resolve small flooding problems of high priority for private property flooding or flooding in the public right-of-way.		Seattle Public Utilities	

Property Protection Actions

What King County heard	How this informs King County's approach in the 2024 Flood Plan
The types of properties at risk of flooding and their vulnerability to floods vary greatly throughout King County, resulting in a diverse range of both suggested approaches for reducing risks to properties and opinions on those approaches. Despite that variety, there was uniformly strong support to provide technical assistance to property owners in at-risk areas to transition to land uses that better accommodate flooding, as well as to support those who repeatedly experience flooding. Elevating, floodproofing, and otherwise retrofitting properties were generally popular approaches to property protection and often discussed when input was sought from community members and partners. Advocates for these approaches noted permitting as a challenge for adapting properties in the floodplain, as well as regulatory changes that are needed to support certain approaches. Some community member and partners prefer acquisition and, less frequently, managed retreat for at-risk properties, with these strategies eliminating risk, not just reducing risk. Concerns expressed included widespread acquisition of lower value properties, which can lead to displacement of populations that may be challenged to find safe, affordable housing elsewhere. This led to discussions of creative financial assistance solutions for low-income populations to help them adapt their properties or support relocation as potential remedies for disproportionate impacts.	King County has a long history of adapting and acquiring at-risk properties. The number of at-risk properties will increase as climate change worsens flooding, which necessitates King County to work with a wider array of strategies for reducing or eliminating risk. This may include new types of retrofits, financial support or incentives that minimize upfront cost burdens, and efforts to increase flood insurance adoption. Approaching property protection with equity in mind will be a key element of these activities to support populations with limited capacity to adapt. Activities under Property Protection actions are presented for Structural Elevations, Acquisitions, Relocations, and Insurance.

Structural Elevations

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Continue King County's home elevation program to support the elevation of structures in flood hazard areas.		King County FCD	
Promote King County's Home Elevation Program — Explore partnership opportunities to expand the program to all flood hazard areas where conditions are favorable for elevations and provide technical assistance to property owners to understand feasibility and funding options for home elevation.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Water-Dependent Recreation Structures Technical Assistance — Coordinate with NOAA Fisheries and the Washington Department of Fish and Wildlife (WDFW) on a technical assistance program to help mitigate risk to water-dependent infrastructure on public and private property. This is primarily an issue on Lake Sammamish, where lake level fluctuation is more than double that of Lake Washington.		King County FCD	
Farm Safety Strategy — Develop a farm safety strategy that focuses on a range of alternatives to placing fill in the valley, including, but not limited to, elevated platforms and shared farm pads; constructing farm pads out of large culverts so that water can still pass through them; and removing fill (e.g., Snoqualmie Valley Trail) to provide more capacity for farm pads, offsite storage outside floodplain, floating structures, etc.		Snoqualmie Valley Watershed Improvement District Snoqualmie Valley Preservation Alliance	(or undetermined)
Elevating Infrastructure in the Agricultural Production District (APD) — Explore opportunities to elevate farm infrastructure in constrained reaches of the Snoqualmie Valley. The original program was created in 2011 to help farmers elevate infrastructure, such as barns, or to design and construct other non-fill solutions, such as elevated platforms. According to the Lower Valley Needs Assessment, there are 118 barns in the APD inside the 1 percent annual chance floodplain. Opportunities could be informed by the Lower Snoqualmie Compensatory Storage Study.		Snoqualmie Valley Watershed Improvement District Snoqualmie Valley Preservation Alliance	(or undetermined)

Acquisitions

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Ensure that management and stewardship of lands acquired for flood mitigation or multi-benefit purposes aligns with King County guidance related to encampment procedures and protocols.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Develop a pre-acquisition process for evaluating factors such as the equity implications and cultural interests affected by a potential acquisition, and the effects to neighborhoods and communities of converting private property to public open space. Incorporate geospatial decision support tool to be developed as part of recommendation under structural projects for advancing multi-benefit projects.		King County	
Evaluate whether stormwater retrofits or other resilience improvements could provide effective flood risk reduction in lieu of acquisition in areas that are not ecologically significant or not connected to a capital project need.		King County	
Countywide Strategic Acquisitions — Acquire properties to reduce flood risk and support integrated floodplain management principles, including properties that are not associated with an adopted Capital Investment Strategy or any other existing capital projects.		King County FCD	(or undetermined)

Relocations

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Relocation Planning — Identify high-risk properties or neighborhoods where managed retreat may be preferred or necessary, including retreat from severe channel migration zones and coastal, landslide, and alluvial fan hazard areas.		King County	

Insurance

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Encourage the purchase of flood insurance and collaboratively work with partners to design a social marketing campaign or other similar effort with a goal of increasing flood insurance policies held in King County.		King County	

Natural Resource Protection Actions

What King County heard	How this informs King County's approach in the 2024 Flood Plan
Various natural resource protection actions are generally a popular approach to flood risk reduction, especially due to their ability to provide benefits that support complementary objectives, such as fish habitat, recreation, and open space access. Over 75 percent of online survey respondents supported protecting upper watershed areas and preserving wetlands to slow the flow of water downstream. Forty-one percent supported working with communities and businesses in floodplains to protect and restore the environment and find ways to incorporate natural elements into projects in the most developed areas. Community members and partners often suggested nature-based solutions for mitigating erosion, reducing stormwater runoff, increasing floodwater storage, recharging groundwater and aquifers, and reducing overall impacts on built environments. Frequently suggested approaches include open space protection, Green Stormwater Infrastructure, and floodplain reconnection, including via levee setback. Some community members expressed the perspective that natural resource protection actions are in conflict with existing land uses, such as agriculture- and water-dependent commerce. Most often in these cases, the solution was for King County to work with potentially affected property owners on agreeable strategies to support existing land uses in the floodplain.	King County recognizes that one of the best means of reducing flood risk is preserving existing ecological processes and protecting floodplains, which reduce the creation of new flood risks. Community support for natural resource protection is reflected in King County's history of voter-approved measures to fund land conservation, which have greatly enhanced King County's ability to protect critical areas, such as floodplains and river corridors. In addition to natural resource protection, King County is prioritizing capital projects with multiple benefits, such as many of the projects detailed under Structural Projects. These priorities reflect the extensive input King County heard about serving the different needs in the floodplain. The focus on integrated floodplain management during the planning process also informed the County's proposed activities in outreach and technical assistance for farmers in the floodplain, which will support multi-beneficial solutions to floodplain management. Activities under Natural Resource Protection actions are presented for Large Wood in Rivers & Streams and Habitation Protection & Restoration.

Large Wood in Rivers and Streams

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Through coordination among King County DNRP, the King County Sheriff's Office, and other agencies as necessary, **review and update King County's procedures related to naturally occurring large wood in rivers and streams**, consistent with the policies and other recommendations outlined in this Flood Plan, including the recognition that wood is an integral element of aquatic habitat necessary for ESA-listed salmon and moving wood incurs significant mitigation expense.		King County	
Review and update King County Public Rule LUD 12-1 (effective April 30, 2010), which addresses procedures for considering public safety in development and design of capital projects that include placement of wood in rivers and streams of King County.		King County	

Habitat Protection and Restoration

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Headwaters and Floodplain Acquisition and Protection — Continue annual fee and easement acquisition of natural lands, providing preventive and natural resource protection benefits. Projects occur countywide and can occur either in upland areas that add recreational and watershed function benefits or in floodplain or adjacent environments that prioritize ecological restoration and salmon recovery.		King County	
Water Resource Inventory Area (WRIA) Grants — Provide annual grant funding for salmon recovery and riverine habitat restoration.		King County FCD	
Evaluate King County's River Facility Inventory to identify facilities that no longer serve a functional purpose and develop a project portfolio for obsolete facility removal and site restoration.		King County	
Work with farmers to **implement riparian buffers, native plantings, and flood resilience measures** on agricultural lands in the floodplains.		King County	
Identify and implement **wetland restoration and protection activities** to mitigate flood risk.		King County	
King County Integrated Drainage Program (IDP) — Provide expanded drainage services to rural King County landowners in the non-built (i.e., natural) environment using a multi-objective approach to provide drainage improvements, mitigate local flood hazards, and enhance fish passage and aquatic and riparian habitats.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Open Space - River Corridors Grants — Provide annual funding to support projects that restore the natural functions of rivers, create or restore public access, and/or increase public awareness of river corridors as valuable natural resources. This program incentivizes multi-benefit projects that integrate recreation and habitat restoration with larger floodplain management efforts.	 	King County	

Emergency Services Actions

What King County heard	How this informs the County's approach in the 2024 Flood Plan
Much of the input King County received about emergency services indicated a desire for improved communication during emergency situations. Specifically, over 65 percent of survey responses stated that communicating flood evacuation routes and road closure information, in real time, was one of the top three important actions needed. Well over half of all community input received on the topic identified a need for improved coordination among government agencies during times of flooding. Specifically, some requested that King County's role and responsibilities during emergencies be better defined, especially related to coordination with incorporated areas. People with experience addressing local flooding emergencies and input from across the county stated that King County should increase its coordination with community organizations during emergencies, as well as build capacity for community organizations to respond to emergencies. Other topics discussed included providing equitable services and resources during emergencies, translating emergency information into multiple languages, sharing translated information in multiple ways, and providing affected low-income populations, especially renters, with additional support, if needed.	King County provides many of the services and resources that community members and partners suggested, but the input received through the 2024 Flood Plan development process indicates a higher demand for emergency flood services and the need to provide these services more equitably. King County intends to increase its efforts in emergency service provision with increased local coordination, communication that serves local needs (including translated information), and support for property owners and renters. Activities under Emergency Services actions are presented for Flood Warning & Emergency Response.

Flood Warning and Emergency Response

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Emergency Alert and Warning — Maintain the KCInform and Alert and notification system to provide real-time life-saving emergency messages to county staff, city jurisdictions, and the public.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Emergency Coordination — King County Office of Emergency Management (OEM) is the coordinating entity for county government during emergency operations in all of the five mission areas (Prevention, Protection, Response, Recovery, and Mitigation). The various county departments and other partners provide capabilities to meet the needs of the operation. During Response operations, the King County OEM, through the Emergency Operations Center, coordinates and facilitates operations activities, especially when they involve more than one county agency or more than one jurisdiction, are complex in scope or have a unique nature, or are in other situations at the request of the departments and partners. Primary roles of King County OEM include resource management and supporting situational awareness.		King County	
Emergency Public Information — Facilitate local and regional message coordination. Manage the King County Emergency Management Blog to share public information messages with partners. Coordinate the cross-jurisdictional, cross-discipline, public information/ communicators group for message collaboration.		King County	
King County Road Alerts — Provide email and text alert services for road conditions in unincorporated King County, including weather- and flood-related road closures and natural disasters. Alerts are also posted on X (formerly Twitter).		King County	
My Commute Website/Map — Provide public travel alerts on a web map with road closures and restrictions, including flooding or landslides. Users can select each reported location to see more information on cause and anticipated duration of closure/restriction. Users can also access the images from traffic cameras located across the county to view road conditions in real time. Most of the information is for County-managed roads in the unincorporated area, but some information is provided by other agencies such as the Washington State Department of Transportation (WSDOT).		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Post-Flooding Bridge Inspection — Following high-flow events, perform safety inspections on a select set of bridges, looking for scour, road overtopping, and debris buildup in the most impacted flooded areas.		King County	
Regional Coordination — Facilitate regional coordination of emergency management activities with county agencies, other jurisdictions, and the private sector to support information-sharing and other activities, as well as lend support to minor issues. This coordination is scalable from routine operations to regional coordination and can include enhanced operations for specific threats, incidents, or special events.		King County	
Regional Flooding Exercise — Conduct annual regional flooding exercises to include multiple agencies with flood response capability, complete evaluations, and create a lessons-learned report to be submitted annually to CRS.		King County	
Roads 24/7 Helpline — This helpline is staffed with customer service agents to perform call intake of county road issues, including storm safety and flooding-related incidents.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Stormwater Emergency Response — Provide emergency response services to emergent situations in which flooding, erosion, or pollution in or along the stormwater drainage system is causing or imminently threatens to cause a severe hazard to public safety, public health, or aquatic life. The stormwater drainage system includes both natural and manmade features that convey, store, infiltrate, or otherwise manage stormwater runoff in unincorporated King County.		King County	
Continue to provide flood warning services, including operating a Flood Warning Center, performing field flood monitoring, coordinating with local emergency management offices and first responders, providing notifications to the public and media, and otherwise ensuring that information about impending or active flooding is communicated to the public.		King County FCD	
Community Sandbag Distribution — Provide sandbags to community members at scattered sites throughout King County during flood season as a preparedness measure.		King County FCD King County Seattle Public Utilities	
Periodically review and update the flood warning program to account for changing risk and to improve flood warning communication strategies to align with community preferences for receiving this information, including identifying ways to provide flood warning messages to those experiencing homelessness who live in at-risk areas.		King County	
Identify mechanisms to improve cross-agency emergency response coordination.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Hazard Mitigation Plan Update — Maintain the King County Regional Hazard Mitigation Plan and support development of mitigation strategies aimed at reducing risk. Provide technical assistance with planning efforts and grants to mitigate flood risk.		King County	
Flood Warning Center IT Upgrades — Replace outdated Flood Warning technology with new customized systems that allow users to access critical data. The project will plan, design, and implement new systems, which includes testing, training, and documentation.		King County FCD	
Integrate Floodzilla information into King County Flood Warning Program — Floodzilla is a dynamic, distributed flood monitoring system that allows landowners to share real-time information during floods. As a resource used by the local Snoqualmie Valley community, there are opportunities for King County to use this information to augment existing flood warning services in that area.		Snoqualmie Valley Preservation Alliance	
Duwamish River Flood Preparedness (2024–2035) — Interim flood reduction, prevention, preparedness, and response activities to minimize risk and consequence of Duwamish River overtopping into South Park communities until a long-term sea level rise-related tidal flooding adaptation plan is implemented.		City of Seattle	
Support property owners with resources for on-site flood response action plans and other short-term response tools.		King County	 (or undetermined)

Structural Project Actions

What King County heard	How this informs the County's approach in the 2024 Flood Plan
Many ideas put forward through the 2024 Flood Plan development process involved new capital projects or expanded implementation of the types of capital projects already being implemented in King County. Improving the flood-resilience of roads throughout King County was identified as a priority theme across all community input. Increasing flood volumes and frequencies have overwhelmed culverts in many locations, and community members and partners suggested expanding efforts to increase conveyance capacity to reduce flooding, especially of roads. Another suggestion involved considering increased floodwater storage at existing dams, including those that are not used primarily for flood control. A notable difference in input was that those who represented largely underserved communities wanted to explore new locations for structural projects to reduce flood risk (63 percent) and ways to improve existing drainage pumps and floodgates (67 percent).	King County will evaluate the feasibility and opportunities for implementing numerous ideas suggested during the 2024 Flood Plan development process. Identifying opportunities for stream daylighting and expanding conveyance capacity through culvert replacements builds on existing King County efforts and will be more practical to initiate, while increasing floodwater storage at federally operated dams (e.g., Howard Hanson and Mud Mountain) would be a long-term process that would depend on the feasibility and the willingness of federal partners, in addition to likely depending on dam relicensing schedules. Activities under Structural Project actions are presented for Structural Actions.

Structural Actions

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Storm Drainage Rehabilitation and Improvement Program — Annual program to replace failing and undersized conveyance infrastructure.		City of Issaquah	
Flood Risk Reduction Grants — Provide annual grants to focus on localized flooding and surface water needs not associated with King County's major rivers.		King County FCD	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Subregional Opportunity Fund — Provides funding equal to 10.23 percent of the FCD tax levy raised in each jurisdiction to allow jurisdictions to carry out local flood reduction improvements, local stormwater control improvements, and watershed management activities.		King County FCD	
Update the King County *Water and Land Resources Project Management Manual* to include multi-benefit considerations early in the project development process (no later than alternatives analysis) so that multi-benefit opportunities are identified and considered across all projects and capital project design considers climate change projections.		King County	
Develop a geospatial project decision-support tool to inform the development of projects that will advance multi-benefit outcomes, including layers that identify different program priorities for acquisitions and capital projects.		King County	
River Facility Inventory Asset Management System — Update the river facility inventory of levees and revetments in King County to a geospatial asset management system.		King County	
Improve Road Safety in Flood-Prone Areas — Assess opportunities to improve flood-safe road access, map current and possible evacuation routes, and explore feasibility of priority resilient evacuation road projects.		King County	(or undetermined)

Public Information

What King County heard	How this informs the County's approach in the 2024 Flood Plan
Public comments uniformly requested more frequent public information linking people to information and resources. This included expanding outreach to youth, small businesses, local governments, and residents, especially those new to King County, regardless of race, income, or access to power. There was a request to maintain the engagement process used in the Flood Plan process, which included the dual goals of raising awareness about flood risk and preparedness resources and gathering public input to inform the plan itself. Community members also requested information about how climate change will affect flooding, the value of wetlands and other natural areas, and the public and environmental health impacts that occur during and soon after flooding. Public input also pointed to a need to better communicate information about flood risk through increased transparency and outreach. Many community members described the desire for transparency around property risks, including requiring flood risk disclosures when renting or buying a property and communicating risks to property owners that are in levee or dam breach flood risk areas. Promoting awareness and encouraging adoption of flood insurance were also frequently suggested as desired public information activities. In coordination with property protection practices, it was also suggested that King County educate people about resilience measures that can be taken and available resources to reduce flood risk.	King County has multiple public information programs that conduct a wide array of education and outreach efforts. King County will continue these programs and update them to account for the changing nature of flood risk and the changes in how flooding is addressed. King County will also advance new or expanded efforts to increase transparency around risk, such as for those that reside in the floodplain or in dam breach risk areas, as well as promote risk reduction activities, such as purchasing flood insurance. Outreach to vulnerable populations and increasing the accessibility of flood risk information will also be high priorities. King County will continue to provide new information about flood risk to the public as studies and modeling provide new insights. Activities under Public Information are presented for Flood Hazard and Preparedness Education and Outreach, Technical Assistance, and Community Capacity Building.

Flood Hazard and Preparedness Education and Outreach

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Provide translated educational materials and emergency information, including King County agency contacts, during times of emergency.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Flood Risk Training for Real Estate Professionals — Provide training to mortgage lenders, realtors, and insurance agents about flood risks so they can better share that information with clients.		Stakeholder identified	
Improve Access to Flood Preparedness Materials — Collaboratively engage diverse audiences to co-create effective flood preparedness outreach. This may require different graphics, address broader topics, and use different methodologies to meaningfully reach different cultures and communities. Also identify tools and implement preparedness outreach to those experiencing homelessness who live in at-risk areas, specifically riparian areas.		King County	
Develop a program for public information to connect floodplain managers and partners to collaboratively create and implement more targeted outreach to change behavior and build more resilient communities.		King County	
Analyze the feasibility of map information improvements that would produce interactive web-based mapping tools to show inundation areas and flood depths at various modeled high-flow conditions on major rivers using existing information and models already available to the public, such as those used for FEMA's Flood Insurance Rate Map studies and reports.		King County	
All Hazard Public Education Program — Provide personal preparedness education to the public in unincorporated King County, as well as support hazard education with local jurisdictions.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Stormwater Education Program — This outreach program is designed to educate landowners about the importance of stormwater controls, including flow control, which contributes to reductions in downstream flooding.		King County	
Risk Reduction Support via Grants — Provide coordination and support to agencies and jurisdictions pursuing grants to mitigate flood-related risks, such as Building Resilient Infrastructure and Communities (BRIC), Hazard Mitigation Assistance (HMA), Flood Mitigation Assistance (FMA), and High Hazard Potential Dam (HHPD) Grant Program.		King County	
Dam Safety Education Program — Provide information to communities, businesses, and jurisdictions about dam hazards. Coordinate with dam owners and operators on dam safety protocols and response activities. Work with dam owners and operators of High Hazard Dams to look at opportunities for improvements. Assist with developing grant applications for dam mitigation work.		King County	
Tidal/Riverine Flooding Connections — Provide resources about the interdependencies among riverine, tidal, and coastal influences on flooding, including potential impacts and roles and responsibilities for preparedness and response.		King County	

Technical Assistance

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Agricultural Drainage Assistance Program (ADAP) — Provide technical and financial support to agricultural property owners to improve drainage of agricultural lands without increasing flood risk or placing fill in the floodplain.		King County	
Stormwater Complaint Program — Field drainage complaints, determine whether a King County program or interest should be involved with a resolution, and provide public information.		King County	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Stormwater Engineer Review Program — Address flooding and drainage complaints requiring a deeper level of analysis than provided by the complaint program. Determine whether a King County program or interest should be involved with a resolution and/or provide technical assistance to private landowners.		King County	
Stormwater Engineer Studies Program — Address flooding and drainage complaints requiring a deeper level of analysis or with a greater breadth of scope than is provided by the Engineer Review Program. Determine whether a King County program or interest should be involved with a resolution and/or provide technical assistance to private landowners.		King County	
Develop and provide information about permitting requirements and potential strategies related to home resilience. Improved technical services are an investment that would provide more readily available information so builders, property owners, and renters could understand flood hazard-related regulations and more successfully evaluate the building of flood-safe structures.		King County	
Risk Reduction Support via Grants — Provide coordination and support to agencies and jurisdictions pursuing grants to mitigate flood related risks, such as BRIC, HMA, FMA, and HHPD.		King County	
Beaver Education — Provide educational information about the role of beavers in the Pacific Northwest and provide landowners with beaver management resources, management tools, and technical expertise to limit flooding and property damage from beaver activity.		King County	
Snoqualmie Valley Beaver Management Pilot Program — Develop and implement a program to mitigate beaver-caused flooding and drainage issues in the Snoqualmie Valley Agricultural Production District while supporting beaver/human coexistence. This program will: (1) provide base beaver population data; (2) deliver technical assistance and beaver-related flood reduction education to agricultural producers; (3) offer cost-sharing and free technical guidance; and (4) provide on-site management implementation, installation, and maintenance assistance.		Snoqualmie Valley Preservation Alliance	

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Provide education and outreach to agricultural communities about floodplain capacity and the purpose of regulations that limit fill.		Snoqualmie Valley Preservation Alliance Snoqualmie Valley Watershed Improvement District	 (or undetermined)

Community Capacity Building

Activity Name and Description	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Flood Resilience Improvement Program — Develop a comprehensive program to raise awareness about flooding, increase flood preparedness, reduce flooding impacts, and increase community resilience. Engage with communities and community-based organizations to identify their needs in building flood resilience and provide support to achieve their flood resilience goals.		King County	

4.5 Comprehensive Risk Mitigation Strategy–Capital Projects

This section includes activities that will eventually result in on-the-ground construction work, including building flood control infrastructure, resilience improvements to the built environment, and restoration of natural environments. The activities in this section are organized by watershed location because the ways that flood hazards are managed vary by the landscapes in which they occur, the characteristics of the flood process, and the resulting impacts. In this way, the structure of this section reflects how a diverse toolkit of flood risk reduction strategies can be applied to effectively respond to the conditions of a localized area, subbasin, or watershed.

What King County heard	How this informs the County's approach in the 2024 Flood Plan
The substantial input received on capital projects spanned suggestions from restoration to new flood control facility construction, with these interventions proposed across all forms of flooding. Addressing on-road flooding through elevating roads, increasing bridge spans, or improving conveyance under and around roads were some of the most frequently discussed capital project ideas, with flooding on roads in valleys being a common hazard. While new flood control structures, such as levees or floodwalls, were not common suggestions from stakeholders, some new structures were advocated for in high-risk areas. Community members and partners generally supported maintenance of and improvements to existing levees, dams, and other flood control structures, especially where they protect key infrastructure, industry, or agricultural land. Numerous community members and government partners supported aligning structural solutions with environmental priorities or balancing these solutions with mitigation efforts. Capital projects that provide multiple benefits were popular throughout the planning process, with many suggestions for levee setbacks, aquatic and riparian enhancements, and culvert removal, which support fish habitat, among other benefits.	King County's approach to capital project planning and implementation reflects the incorporation of input from diverse interests and support for contextually appropriate solutions to flood hazards. Many of the capital projects provide multiple benefits, especially habitat restoration, open space access, climate resilience, and locally sustainable agriculture. Priorities identified in the planning process that are proposed for implementation also include safe transportation, with road flooding being a frequently mentioned issue. Many of the capital projects support this priority through conveyance capacity increases and road elevations. Recognizing the complex challenges and potential impacts of implementing flood control infrastructure, planning processes, and alternatives studies that will work with partners to identify appropriate solutions are also integral to the Comprehensive Risk Mitigation Strategy. Restoration efforts to increase flood storage and strategic floodplain reconnection support habitat goals, agriculture, and safe transportation, which were frequently mentioned in the planning process. The many levee setbacks proposed support these priorities while also retaining flood protection to property and infrastructure. Activities under capital projects are presented below, by watershed.

South Fork Skykomish/Snoqualmie River Watershed

South Fork Skykomish River

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Timber Lane Village Acquisitions — Acquire and remove homes along a stretch of the South Fork Skykomish River that are endangered by bank erosion, channel migration, and inundation in some places. A risk assessment completed in 2014 and recent updates to channel migration and flood hazard maps provide guidance to prioritize the acquisitions.	Property protection		King County FCD	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Lower Miller River Floodplain Restoration Project — Restore up to 140 acres and several miles of Miller River mainstem, tributary, and side channel habitat to improve salmonid habitat in the South Fork Skykomish watershed.	Natural resource protection		King County	

Upper Snoqualmie River

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Circle River Ranch Risk Reduction — Design South Fork Snoqualmie River flood risk reduction project to reduce flood and channel migration risk to homes and infrastructure in the Circle River Ranch community.	Structural projects		King County FCD	
Ribary Creek Improvements — Design, permit, and construct improvements to Ribary Creek levees and culverts to reduce flooding of State Route 202 and a retail center. Potential solutions include culvert replacement, gravel removal, and levee setbacks.	Structural projects		King County FCD	
Pump Station Revetment Repair — Implement improvements to the facility to reduce future erosion risk to the pump station operated by the City of Snoqualmie.	Structural projects		King County FCD	
Floodplain Conveyance Improvements Phase 1 — Identify potential solutions to reduce impacts from Middle Fork Snoqualmie River overflow channels in North Bend.	Structural projects		King County FCD	
Middle Fork Snoqualmie Residential Flood Mitigation — Acquire structures in the Middle Fork Snoqualmie River channel migration zone to reduce the risks from channel migration and bank erosion in the lower 5 miles of the river, prioritizing the 18 parcels with structures in the severe channel migration zone.	Property protection		King County FCD	
North Fork Snoqualmie Residential Flood Mitigation — Acquire flood-prone properties in the North Fork Snoqualmie basin to reduce the risk of flood, erosion, and channel migration damage and secure footprints for future capital projects.	Property protection	 	King County FCD	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Upper Snoqualmie Residential Flood Mitigation — Acquire flood-prone properties or elevate individual structures in the upper Snoqualmie River basin to eliminate the risk of flood damage when Snoqualmie River flows overtop the existing levees.	Property protection		King County FCD	
North Fork Snoqualmie Confluence Revetment Removal — Remove obsolete left bank riprap on North Fork (at North Fork/Middle Fork confluence). Involves a hydraulic model, demolition plan, permitting, and construction.	Natural resource protection		King County FCD Snoqualmie Tribe	
Tanner Landing Floodplain Reconnection – Analysis, design, and removal of a revetment along the left bank of the Middle Fork Snoqualmie River at the upstream end of Tanner Landing Park.	Natural resource protection		King County	
SE Reinig Road Drainage Improvement Culvert — The existing culvert on SE Reinig Road near North Fork Road SE is inadequately sized, which restricts water flow and causes annual flooding on nearby roadways and private properties. This project will replace the 40-inch corrugated metal pipe to increase water flow and provide fish passage.	Natural resource protection		King County	
Reif Road Levee Improvements — Conduct a feasibility study to determine project scope to reduce South Fork Snoqualmie River overtopping of the Reif Road levee at a 5 percent annual chance or greater flood and construction of improvements to alleviate flood risk.	Structural projects		King County FCD	
264th Avenue NE at State Route 202 Flood Abatement — Replace existing culverts near North Bend on the South Fork Snoqualmie River and raise the roadway to eliminate dangerous conditions from overtopping and roadway flooding on this sole-access road.	Structural projects		King County FCD	
Bendigo Levee Upper North Bend — Provide cost-share funding to the City of North Bend to set back the Bendigo Upper Levee. The project would reconnect 25 acres of floodplain and construct a new levee that meets current engineering guidelines.	Structural projects		King County FCD	
Norman Creek Up Stream 2024 Culvert — Improve SE 92nd Street east of 428th Street and alleviate roadway flooding by installing a new box culvert.	Structural projects		King County FCD	
Tate Creek Scour Repair — Conduct a feasibility study for replacing or improving Tate Creek Bridge.	Structural projects		King County FCD	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
North Fork Bridge #1221 Replacement (Roads CIP #1143969) — Bridge replacement project to reduce the frequency of road flooding and subsequent neighborhood isolation by raising the height of 428th Avenue SE and increasing the hydraulic opening of the bridge.	Structural projects		King County	
Floodplain Conveyance Improvements Phase 2 — Implement improvements to reduce impacts from Middle Fork Snoqualmie River overflow channels in North Bend.	Structural projects		King County FCD	
Mason Thorson Extension Risk Reduction — Identify alternatives and implement a strategy to reduce risks from a constriction on the Middle Fork Snoqualmie River at the Mason Thorson Extension levee. Potential solutions include levee modifications or setbacks.	Structural projects		King County FCD	
Mason Thorson Ells Risk Reduction — Identify alternatives and implement a strategy to reduce risks from a constriction of the Middle Fork Snoqualmie River at the Mason Thorson Ells levee. Potential solutions include levee modifications or setbacks.	Structural projects		King County FCD	
Increase Flood Storage and Conveyance — Identify and remove flood protection facilities on the Middle Fork Snoqualmie River that no longer protect infrastructure or development and take up flood conveyance and storage capacity.	Natural resource protection		King County FCD	
Nintendo Levee Setback — Leverage partnerships to set back the Bendigo Upper Left (Nintendo) levee, maximizing local South Fork Snoqualmie River storage benefits.	Natural resource protection		King County FCD	
Si View Levee Improvements — Increase level of flood protection of the Si View Levee on the South Fork Snoqualmie River to 0.2 percent annual chance flood levels by improving the levee.	Structural projects		King County FCD	
SE Mount Si Road Isolation Risk Reduction — Evaluate and implement solutions to reduce Middle Fork Snoqualmie River flooding of SE Mount Si Road, cutting off access to 415 homes.	Structural projects		King County FCD	(or undetermined)
428th Avenue SE Road Isolation Risk Reduction — Evaluate and implement strategies to reduce Middle Fork Snoqualmie River flooding of 428th Avenue SE Road that can block access to 300 homes. Options include elevating the roadway and replacing culverts to increase conveyance.	Structural projects		King County FCD	(or undetermined)

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
I-90 Flood Risk Reduction Project — Set back the McConkey levee on the South Fork Snoqualmie River upstream of I-90 and confluence with Clough Creek.	Structural projects		King County FCD	(or undetermined)
Bendigo Bridge Replacement — Coordinate with WSDOT and the City of North Bend to replace the 150-foot span of the Bendigo Bridge with a span of at least 400 feet. The bridge currently creates a hydraulic backwater that contributes to flooding.	Structural projects		King County FCD	(or undetermined)
Prairie Acres Right Levee — Set back, raise, or repair the Prairie Acres Right levee to reduce risk to 32 structures and City of North Bend Wastewater Treatment Plant from South Fork Snoqualmie River 0.2 percent annual chance flood flows.	Structural projects		King County FCD	(or undetermined)
Bendigo Upper Right Bank Levee — Set back, repair, or raise the Bendigo Upper Right Bank levee to reduce risk to 18 structures and streets inundated by South Fork Snoqualmie River 0.2 percent annual chance flood flows.	Structural projects		King County FCD	(or undetermined)
Bendigo Lower Right Levee — Setback, repair, or raise the Bendigo Lower Right Bank levee to reduce risk to 129 structures and streets inundated by South Fork Snoqualmie 1 percent annual chance or greater flows.	Structural projects		King County FCD	(or undetermined)
Bendigo Lower Left Levee — Setback, repair, or raise the Bendigo Lower Left Bank levee to reduce risk to five structures and NW 8th Street from South Fork Snoqualmie River 2 percent annual chance and greater flows.	Structural projects		King County FCD	(or undetermined)
Prairie Acres Left Levee — Set back, repair, or raise the Prairie Acres Left Levee to reduce risk to forested and undeveloped agricultural lands by South Fork Snoqualmie River 5 percent annual chance or greater flows.	Structural projects		King County FCD	(or undetermined)

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Sandy Cove — Stabilize bank in public park in City of Snoqualmie along Snoqualmie River.	Structural projects		City of Snoqualmie	 (or undetermined)
Snoqualmie Riverwalk — Purchase property along Snoqualmie River to mitigate flood risk and provide economic development and recreational opportunities.	Property protection		City of Snoqualmie	 (or undetermined)
Tate Creek Floodplain Acquisitions — Acquire floodplain and channel migration zone of Tate Creek (North Fork Snoqualmie tributary) and develop related flood risk reduction project.	Property protection		Snoqualmie Tribe	 (or undetermined)
Upper Snoqualmie Left Bank Floodplain Function Protection — Plan and analysis regarding conservation/protection of well-connected left bank floodplain. Landowner outreach and potential land acquisition.	Natural resource protection		Snoqualmie Tribe	 (or undetermined)
Meadowbrook Reach Restoration Project — Restore floodplain processes within Meadowbrook Slough and adjacent floodplain.	Natural resource protection		Snoqualmie Tribe	 (or undetermined)
City Reach Timber Revetment Renovation — Add more wood to left bank timber revetment to increase structural integrity and improve fish habitat along bank.	Structural projects		Snoqualmie Tribe	 (or undetermined)
City Reach Channel Roughening and Enhancement — Build mid-channel log jam on bar adjacent to Sandy Cove Park to establish flow split, increase shade, and increase pool frequency and complex cover. Enhance side-channel habitat along right bank floodplain to increase channel length and shade, provide slow-velocity habitat, increase cover, and potentially add additional flood storage.	Natural resource protection		Snoqualmie Tribe	 (or undetermined)

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Upper Snoqualmie Right Bank Groin Removal — Remove derelict right bank groin near River Mile 43.5. Project involves a hydraulic model, demolition plan, permitting, and construction.	Natural resource protection		Snoqualmie Tribe	(or undetermined)

Lower Snoqualmie River

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Dutchman Road Revetment Repair — Repair approximately 300 feet of the Dutchman Road revetment. Dutchman Road at this location provides the sole access to residences and business on the west side of the Snoqualmie Valley downstream of Duvall.	Structural projects		King County FCD	
Stossel Revetment Major Repair — Investigate and implement improvements of up to 700 feet of the Stossel Bridge Right Bank revetment as the result of recent damage from two flood events. The project is located downstream of the Stossel Bridge, also known as the NE Carnation Farm Road Bridge.	Structural projects		King County FCD	
Tributary to Horseshoe Lake at Snoqualmie Valley Trail just north of NE Carnation Farm Road (FPS-2373) — Replace existing concrete culvert to improve fish passage and conveyance.	Natural resource protection		King County	
334th Avenue SE at SE 43rd Street Flood Abatement — Construct a drainage system to outfall in the Snoqualmie River where none currently exists to alleviate roadway flooding.	Structural projects		King County FCD	
Fish Hatchery Road Bridge #61B — Strengthen the bridge structure to stabilize it following flood damage, rebuild the east approach roadway to protect it against major flood events in the future, and restore the eroded creek bed and riverbank profile to buffer the bridge against scour.	Structural projects		King County FCD	
Cherry Creek Floodplain Reconnection Phase II — Address the multiple impacts of alluvial fan depositions in the floodplain of the Snoqualmie Valley Agricultural Production District caused by a 2018 avulsion on Cherry Creek. The project is designed to work with and allow natural processes to continue to occur while restoring floodplain habitat for fish and reducing flood risks to down-valley agricultural land and infrastructure in Cherry Valley.	Natural Resource Protection		Snoqualmie Valley Watershed Improvement District	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Langlois Creek Culvert Replacements — Remove and replace the two farthest downstream fish barrier culverts on Langlois Creek with precast concrete box culverts to restore access to 1.23 miles of upstream habitat, potentially benefitting multiple species of native fish and salmonids. Culvert designs are intended to accommodate future increases in flow volumes, flood frequency, and bankfull widths, which will reduce flood risks in the Langlois Creek basin, which encompasses a drainage area of roughly 3 square miles.	Natural resource protection		Snoqualmie Valley Watershed Improvement District	
Langlois Creek Fish Passage Project at NE 24th Street (FPS-2130) — Fish passage project to replace one barrier culvert at a road intersection with a fish-passable structure.	Natural resource protection; structural		King County	
Ames Creek Fish Passage Projects at NE 100th (FPS-1757) and NE 80th (FPS-565) — Fish passage projects to replace two existing barrier culverts with a fish-passable structure at both locations.	Natural resource protection		King County	
Mouths of Unnamed Tributaries to the Snoqualmie River at W Snoqualmie River Road (FPS-2528 & -2529) — Fish passage projects to replace three barrier culverts/flood gates with fish-passable structures.	Natural resource protection		King County	
NE Woodinville Duvall Road at West Snoqualmie Valley Road NE — Both of these roads are major arterials, and the intersection crosses over an alluvial fan of Tuck Creek. The current structures are undersized and cause regular flooding of the nearby agricultural land. This project will add two box culverts to reduce flooding impacts and provide fish passage.	Natural resource protection		King County	
334th Avenue SE and SE 43rd Place Flood Improvement — The area of 334th Avenue SE and SE 43rd Place experiences chronic flooding of public and private property. This project is designed to alleviate neighborhood flooding by constructing a drainage system to flow to the Snoqualmie River.	Structural projects		King County	
Harris Creek Fish Passage Projects on NE Stossel Creek Way (FPS-2176, -157, -638, -5670) — Fish passage projects to replace four existing barrier culverts with fish-passable structures.	Natural resource protection		King County	
Snoqualmie River Farm Floodplain Reconnection — King County will explore ways to reconnect Snoqualmie River floodplain to improve salmon habitat while also protecting farmland and farm structures at the Snoqualmie River Farm (formerly Beyers property) with a feasibility study and project design.	Natural resource protection		King County	(or undetermined)

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Basin 1 Pump Replacement — Replace a relict pump on a tributary to the Snoqualmie River in the Snoqualmie Valley Watershed Improvement District Drainage Basin 1. The drainage pump station provides flood risk reduction from increased precipitation/runoff events during shoulder farming seasons (early spring/late fall). The proposed plan is to update the energy efficiency, resiliency, and fish safety of the pump station.	Structural projects		Snoqualmie Valley Watershed Improvement District	(or undetermined)

Tolt River

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Rio Vista Property Acquisitions — Acquire up to 16 homes in the Rio Vista neighborhood from willing sellers to remove risk of flooding from deep and/or fast flows and landslide hazards that can exacerbate flooding on the Tolt River.	Property protection		King County FCD	
Acquisition in Leveed Reach — Acquire at-risk homes from willing sellers in the leveed portion of the Tolt River.	Property protection		King County FCD	
Lower Tolt River Acquisition — Purchase property from willing sellers in a flood- and channel-migration-prone area along the lower Tolt River to reduce flood risk and allow for future levee setbacks.	Property protection		King County FCD	
Tolt Natural Area Property Acquisitions — Acquire five properties at risk from flooding, erosion, avulsion, and potential levee breach in the Tolt Natural Area on the Tolt River.	Property protection		King County FCD	
San Souci Neighborhood Buyout — Acquire homes that are at high risk for damage from channel migration and avulsion from willing sellers in the vicinity of the former San Souci neighborhood.	Property protection		King County FCD	
Lower Frew Levee Setback — Design and construct Lower Frew Levee setback to increase sediment storage and floodwater conveyance on the Tolt River, protect future development, reduce State Route 203 flooding and damages, and improve high-priority habitat.	Natural resource protection		King County FCD	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Upper Frew Levee Setback — Design and construct an Upper Frew Levee setback on the Tolt River to reduce impacts from levee overtopping and damage to the Snoqualmie Valley Trail Bridge. The project should increase sediment storage and floodwater conveyance, protect adjacent development, and reduce potential damage to trail bridge.	Structural projects		King County FCD	
Tolt River Natural Area Acquisition — Acquire up to four additional properties in the channel migration zone of the Tolt River in the vicinity of the Tolt Natural Area.	Property protection		King County FCD	
Remlinger Levee Improvements — Evaluate options to set back or repair and improve a frequently damaged section at the downstream end of the Remlinger Levee.	Structural projects		King County FCD	
Girl Scout Levee Setback — Set back the Girl Scout Camp Levee to reduce flood risks to the Girl Scout Camp and Remlinger Farms, improve levee integrity, increase the lateral migration area and area for ongoing sediment deposition, reduce long-term levee maintenance costs, and improve instream, floodplain, and riparian habitat functions.	Natural resource protection; structural		King County FCD	
Holberg Levee 2019 Repair — Repair approximately 150 linear feet of erosion on the face the Holberg Levee, discovered during the 2018 post-flood inspections.	Structural projects		King County FCD	
Tolt Dam Debris Boom Replacement — Replace the existing log boom protecting the water intake and spillway.	Structural projects		Seattle Public Utilities	
Tolt Dam Spillway Rehabilitation — Tolt Dam spillway rehabilitation to prevent erosion and downstream turbidity impacts on aquatic species.	Structural projects		Seattle Public Utilities	
NE Tolt Hill Road Elevation and Levee Setback Feasibility Study — Conduct a feasibility study of modifying NE Tolt Hill Road and setting back the Tolt River Levee Left Bank levee downstream of State Route 203. The levee and road overtop during minor to moderate Tolt River and Snoqualmie River floods, which limits access to and from the Snoqualmie Valley and the City of Carnation during flood events.	Natural resource protection; Structural projects		King County FCD	(or undetermined)

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Levee Setbacks — Design and construct levee setbacks on the Tolt River for the Highway to Trail Bridge Levee.	Natural resource protection; Structural projects		King County FCD	(or undetermined)
Levee Setbacks or Improvements — Design and construct levee improvements to the Holberg and Edenholm levees on the Tolt River.	Natural resource protection; Structural projects		King County FCD	(or undetermined)
Private Revetment Removal or Improvements — Remove or modify privately constructed revetments on the Tolt River to improve protection and reduce adverse impacts.	Natural resource protection; Structural projects		King County FCD	(or undetermined)
Lower Tolt Assessment and Planning — Assess lower Tolt confluence area for large-scale opportunities to improve river and floodplain processes, salmon habitat, and local and regional transportation and climate resiliency. This includes Hwy 203, NE Tolt Hill Road, King County Parks, Private Property, City of Carnation, and more.	Natural resource protection		Snoqualmie Tribe	(or undetermined)

Raging River

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Alpine Manor Acquisitions — Acquire at-risk properties from willing sellers in areas where structures are at risk from channel migration or flooding.	Property protection		King County FCD	
Raging River Bridge to Bridge Assessment — Conduct assessment of river and floodplain functions, as well as dikes and levees within the Raging River bridge to bridge reach, to evaluate their impact on river and floodplain processes. Investigate acquisitions and facility setbacks and removals.	Natural resource protection		Snoqualmie Tribe	(or undetermined)

Lake Washington/Cedar/Sammamish River Watershed

Cedar River Basin

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Cedar River Gravel Removal Renton— This project removes gravel along the lower 1.25 miles of the lower Cedar River to maintain 1 percent annual chance level of flood protection for the City of Renton. The project also includes implementation of several specific mitigation measures to offset environmental impact.	Structural projects		King County FCD	
Dorre Don Neighborhood Improvements — Evaluate options to address flood and erosion risks and acquire at-risk properties in the Dorre Don Neighborhood.	Property protection; structural projects		King County FCD	
Cedar River Pre-Construction Strategic Acquisition — Acquire properties that several large FCD capital projects depend on, namely the levee setback projects at the WPA, Rutledge-Johnson, Rhode, Getchman, Lower Jones Road, Elliott Bridge, Byers, and Rafter Park levee or revetment segments. Priorities for acquisition will be directed by the FCD.	Property protection		King County FCD, King County	
Royal Arch Reach Acquisitions — Acquire floodplain properties for future reach-scale floodplain reconnection and restoration, from State Route 169 to Highway 18.	Natural resource protection		Seattle Public Utilities	
Madsen Creek Channel Realignment — Create a single channel for Madsen Creek through Renton and King County away from private property prior to connecting to the Cedar River. The project would eliminate a sediment basin and a high-flow bypass and restore the creek to a self-sustaining channel with an alluvial fan capable of passing fine sediment. The proposed alignment would move the creek away from and reduce flood risk to properties in Renton and King County.	Natural resource protection		City of Renton	
Cedar River Lower Rutledge-Johnson Floodplain Restoration — Multi-benefit floodplain restoration project adjacent to State Route 169, Cedar River Trail, and recently completed Jan Road Levee Setback project.	Natural resource protection		King County	
Molasses Creek Barrier Removal Project — A fish passage project that will remove a fish passage barrier at the mouth of Molasses Creek.	Natural resource protection		King County	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Molasses Creek Culvert Replacement Project at SE Petrovitsky and 134th SE (FPS-1602, -650) — Replace two failing culverts with two fish-passable structures.	Structural projects		King County	
Belmondo Levee 2020 Repair — Repair approximately 100 feet of damage observed near the upstream end of the revetment. Damages include erosion and scour, which have resulted in loss of toe and bank rock, over-steepened and undercut banks, and localized bank erosion.	Structural projects		King County FCD	
Cedar River Downstream Improvements — Improve Cedar Grove Road near Byers Road SE to alleviate roadway flooding by raising the road through the application of a thick layer of overlay.	Structural projects		King County FCD	
Cedar River Trail 5 Revetment 2020 Repair — Repair the flood protection facility Cedar River Trail 5 to address erosion issues along approximately 150 feet of the 300+ foot revetment near the King County Cedar Mountain Bridge.	Structural projects		King County FCD	
Herzman to Camp Freeman Levee Setback and Repair — Remove and set back a portion of the Herzman Levee damaged by the 2020 flood event, located along the right (west, northwest) bank of the Cedar River in unincorporated King County, and repair damaged portions of the Camp Freeman Levee. The project will reduce erosion risks to private properties and SE Lower Jones Road and improve riparian and aquatic habitat.	Natural resource protection; Structural projects		King County FCD	
Tabor-Crowall-Brodell Revetments — Repair the Tabor-Crowall and Brodell revetments, which have become over-steepened in recent flood events, and provide habitat improvements.	Structural projects		King County FCD	
Lower Jones Neighborhood Improvements – Acquire at-risk properties and evaluate options to address flooding of SE Jones Road that can result in temporary road closures.	Property protection; structural		King County FCD	
Byers Road Neighborhood Improvements – Acquire at-risk properties and complete a feasibility study to investigate options to address widespread flooding and channel migration risks along 1 mile of floodplain along the left bank of the Cedar River.	Property protection; structural		King County FCD	
Landsburg Dam Debris Passage Improvements — Passing large debris through Landsburg Diversion Dam is challenging and could potentially stack up fast enough against the dam to jeopardize its structural integrity by direct impacts or rapid erosion.	Structural projects		Seattle Public Utilities	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
WPA Levee Setback — Remove and set back the WPA Levee along the Cedar River. This project would reconnect floodplain habitat and could reduce erosion risk to the downstream Belmondo Levee.	Natural resource protection; structural projects		King County	(or undetermined)
SE Petrovitsky Road at 151st Avenue SE – The culvert under SE Petrovitsky Road and 151st Avenue SE is failing, and the road is at risk of collapsing. Due to the failed pipe, the outlet often plugs and water overtops SE Petrovitsky Road. Replace the culvert and add a new inlet structure with a debris cage to prevent the system from plugging. This will also improve outfall from the nearby detention facility.	Structural projects		King County	(or undetermined)
Cedar River Residential Flood Mitigation — Acquire flood-prone properties or elevate or relocate individual structures in the Cedar River basin to eliminate the risk of flood damage when river flows overtop the existing levees.	Property protection		King County FCD	(or undetermined)

Sammamish River/Lake Sammamish Basin

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Peters Creek at West Sammamish River Trail north of NE 90th Street (FPS-941, CLO-132509) — Replace 72-inch-diameter deteriorating metal pipe with fish-passable structure. Improved conveyance.	Natural resource protection		King County	
Trib to Sammamish River at MM Dog Park (FPS-1257, CLO-114463 & FPS-1258, CLO-147289) — Replace two deteriorating culverts with fish-passable structures and improve conveyance.	Natural resource protection		King County	
Trib to Sammamish River at Sammamish River Trail near NE 143rd Steet (FPS-2076, CLO-130643) — Replace existing 24-inch-diameter corroded bottom barrel of culvert with fish-passable structure and improve conveyance.	Natural resource protection		King County	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Daniels Creek Fish Passage Projects at NE 185th (FPS-408) and NE Woodinville-Duvall Road (FPS-170) — Fish passage projects to replace two existing barrier culverts with fish-passable structures at both locations.	Natural resource protection		King County	
Bear Creek Integrated Restoration and Stormwater Projects — Integrated planning and implementation of habitat restoration and stormwater retrofit projects.	Natural resource protection		King County	
Willowmoor Floodplain Restoration — Reconfigure the outlet from Lake Sammamish to the Sammamish River to maintain or reduce current levels of flood risk in the downstream river channel and along the lake shore.	Natural Resource Protection	 	King County FCD	
Allen Lake Outlet Improvements — Evaluate upstream retention/detention options, study road raising options, and prepare a Concept Development Report to analyze option(s), identify the preferred option, and implement the project.	Structural projects		King County FCD	
Sammamish Capital Investment Strategy — Identify and prioritize near-, mid-, and long-term, multi-benefit capital projects and other actions for FCD funding along the Sammamish River.	Structural projects		King County FCD	
East Side Wayne Sammamish/Waynita Restoration — Restore the eastside of the former Wayne Golf Course property (back nine, 31.6 acres). The restoration approach is dependent on results from a feasibility study but could include enhancing Waynita Creek habitat at the mouth, Sammamish floodplain restoration, improving riparian conditions, and creating cold water refuge.	Natural resource protection		WRIA 8	
Little Bear Creek Fish Passage at 134th Avenue NE – Replace three broken concrete pipes that are a partial fish passage barrier and could undermine a city maintenance access road.	Natural resource protection		WRIA 8	
Evans Creek Relocation — Relocate a portion of Evans Creek from an industrial area into open space to reconnect the channel with floodplain wetlands, enhance channel complexity, and restore riparian buffer function.	Natural resource protection		WRIA 8	
Cottage Lake Creek Weir Removal and Restoration — Remove privately owned weir on Cottage Lake Creek. Remove bank armoring and floodplain, add large woody debris, and restore adjacent riparian habitat.	Natural resource protection		WRIA 8	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Cottage Lake Creek Fish Passage Projects at Avondale Road NE (FPS-2098), NE 128th Way (FPS-165), NE 165th (FPS-2296), and NE Avondale & NE 144th (FPS-2099) — Fish passage projects to replace four barrier culverts with fish-passable structures.	Natural resource protection		King County	
Ebright Creek Acquisition and Enhancement – Acquire up to 6 acres along lower Ebright Creek and enhance the mouth of the creek and shoreline of Lake Sammamish.	Natural resource protection		WRIA 8	
George Davis Creek at East Lake Sammamish Trail (ELST) (FPS-2142) — Fish passage culvert replacement is part of ELST South Sammamish Phase 2 project.	Natural resource protection		King County	(or undetermined)

Issaquah Creek Basin

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Bush Street Stormwater Improvements — Conveyance improvement project.	Structural projects		City of Issaquah	
Olde Town Stormwater Improvements — Study to understand and develop solutions to flooding, failing infrastructure, and water quality on the Olde Town area.	Structural projects		City of Issaquah	
Carey Creek Fish Passage Project at 276th SE — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection		King County	
East Fork Issaquah Creek Fish Passage Project at NE High Point Way (FPS-2897) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection		King County	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
East Fork Issaquah Creek Floodplain Restoration Strategy — System-wide study of the benefits of restoring a 3-mile section of the creek in unincorporated King County from West Tiger Mountain at SE 88th, downstream to the High Point Way interchange off I-90.	Natural resource protection		King County	
Carey/Holder/Issaquah Creek Confluence Restoration — New project on former Bonomi farm. Feasibility completed in 2023. Coordinated planning effort between King County Agriculture, Forestry, and Incentives; Ecological Restoration and Engineering Services; Basin Steward; and Parks kicks off in 2024. Cost assumes 45 acres of restoration and 4,500 linear feet of channel work.	Natural resource protection		King County	
Fifteen Mile Creek Bridge #493C Replacement — The current bridge carries SE May Valley Road, a major arterial over Fifteen Mile Creek. The original bridge was built in 1932 and is structurally deficient with substandard rails, narrow width, and a poor hydraulic opening. This bridge replacement project will remove the existing bridge, associated fill, and stream bank armoring that is constricting the creek's flow and creating flooding, scour, and potential water-quality issues.	Structural projects		King County	
208th Avenue SE @ SE 135th Culvert — The existing culvert at 208th Avenue SE and SE 135th Street is in an area where alluvial soils and sediment build up and reduce its capacity to carry flows. This causes frequent flooding on a sole-access road. This project will replace the culvert to increase water flow and provide fish passage.	Natural resource protection		King County	
Issaquah Creek Capital Investment Strategy — Identify and prioritize near-, mid-, and long-term capital projects for FCD funding along Issaquah Creek.	Structural projects		King County FCD	
Momb Revetment 2020 Repair — Repair 30 feet of erosion and 25 feet of slumped bank at the upstream end of the revetment and provide riparian habitat improvements.	Structural projects		King County FCD	
Jerome Revetment 2020 Repair — Repair damage to a revetment along Issaquah Creek damaged during the 2020 flood event. The facility protects three residential properties from bank erosion.	Structural projects		King County FCD	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Issaquah Creek Instream Restoration at Lake Sammamish State Park — Restore 6,600 linear feet of lower Issaquah Creek through Lake Sammamish State Park via extensive large wood installations and strategic floodplain excavations. Restoration will provide significant habitat benefits for Chinook and other salmonids, floodplain and side-channel connectivity, and more functional and complex refuge and foraging habitat.	Natural resource protection		WRIA 8	
Squak Valley Park South Stream and Wetland Restoration —Install log complexes in the main channel and along its banks to encourage pool formation, provide protective cover, and improve habitat diversity and quality. Restore the floodplain and side channel to increase edge habitat. Implement wetland and riparian enhancements. Pursue acquisition of lone remaining privately held parcel to enable full-scale restoration on the right bank.	Natural resource protection		WRIA 8	

Lake Washington Basin

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Juanita Drive Storm Failure at 86th Avenue NE — Resolve flooding and hazardous ice accumulation on residential driveways and roadway shoulder.	Structural projects		City of Kirkland	
Holmes Point Drive NE pipe extension at Champagne Creek — Resolve flooding along the west side of Holmes Point Drive NE.	Structural projects		City of Kirkland	
Silver Spurs Storm System Upgrade — Reduce structure and roadway flooding in a residential neighborhood.	Structural projects		City of Kirkland	
Margaret's Way Trailhead Driveway Culvert (FPS-2737) — Replace culvert with fish passage structure. Existing culvert is corroded and undersized, which causes piping around the inlet to form sinkholes. Improve conveyance.	Natural resource protection		King County	
Lower Coal Creek Drainage Bellevue — Provide feasibility and predesign analysis of possible solutions to reduce flooding problems in the City of Bellevue's Coal Creek neighborhood.	Structural projects		King County FCD	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Taylor Creek Outfall Improvements — Two drainage outfalls along the east rim of Dead Horse Canyon (Lakeridge Park) in South Seattle will be tightlined to allow water to reach Taylor Creek without continued slope erosion and sediment delivery to the creek contributing to downstream flooding. Improvements will also be made to the upstream drainage components of each outfall to reduce flooding on private property and in the right-of-way in King County and the City of Seattle.	Structural projects		Seattle Public Utilities	
98th Avenue NE and NE Juanita Drive — Reduce roadway flooding due to stormwater system surcharge.	Structural projects		City of Kirkland	(or undetermined)
Stream Restoration at 128th Lane NE on Juanita Creek — Stream channel restoration to prevent overtopping that floods an adjacent private parking lot.	Natural resource protection		City of Kirkland	(or undetermined)
25th Avenue NE Ballinger Creek Habitat Restoration and Flood Reduction Project — Ballinger Creek flooding near 25th Avenue NE and NE 195th Street impacts homes and roadways about every two years. The project would restore a 1,500-foot section of Ballinger Creek by daylighting 600 feet of currently piped stream, including 400 feet of stream within a half-acre of restored floodplain storage, installing four fish-passable box culverts, and restoring 700 feet of open channel at the foot of a failing retaining wall.	Natural resource protection		City of Shoreline	(or undetermined)
Thornton Creek Flood Reduction — Flood risk reduction through land acquisition, upsizing of stream culverts, and associated floodplain reconnection.	Natural resource protection		Seattle Public Utilities	(or undetermined)
Lower Taylor Creek Restoration — Address and prevent localized flooding for at least 15 properties by improving drainage infrastructure, restoring the natural drainage system function of approximately 3,000 linear feet of Taylor Creek; eliminating barriers to fish passage; rebuilding and improving natural habitat; and providing equitable opportunities to the community by expanding public access to open space.	Natural resource protection		Seattle Public Utilities	(or undetermined)

Green/Duwamish River Watershed

Green/Duwamish River Basin

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Lower Russell Road Habitat Area A — Excavation of a new large off-channel habitat that will provide rearing and refuge habitat for juvenile Chinook salmon. This project is associated with the Lower Russell Levee Setback project, part of a larger overall flood management strategy for the lower Green River.	Natural resource protection		City of Kent	
Boeing Levee Setback Habitat Rehabilitation — Restore salmon habitat along 0.8 mile of the lower Green River (River Mile 17). A previous levee setback in the project area provides an opportunity for implementing a variety of habitat enhancements within approximately 15 acres of floodplain habitat. The overall goal is to restore floodplain function and improve habitat complexity along the heavily developed lower Green River.	Natural resource protection		City of Kent	
Chinook Wind Extension — Setback/layback shoreline between Chinook Wind Mitigation and Duwamish Gardens to expand salmon habitat and provide connected recreational trail experience.	Natural resource protection		City of Tukwila	
Nelson Creek Side Channel — Restore off-channel salmon-rearing habitat by setting back revetment and reconnecting a segment of historic river channel with the Green River, providing additional flood storage.	Natural resource protection		City of Tukwila	
Relocation of Minkler Public Works Facility — Relocate critical infrastructure to reduce flood risk.	Property protection		City of Tukwila	
S 131st Street Flood Reduction Project — Upgrade creek culverts to prevent flooding and improve habitat and water quality.	Natural resource protection; structural		City of Tukwila	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Gilliam Creek Fish Barrier Removal and Habitat Enhancement — Create fish passage and increase flood storage between Gilliam Creek and the Green River in Tukwila. Gilliam Creek is mostly inaccessible to aquatic species due to the presence of a 1960s era 108-inch-diameter flapgate at the outlet of a 207-foot-long culvert beneath 66th Avenue S.	Natural resource protection		City of Tukwila	
Cecil Moses Tire Revetment — Cecil Moses Park features a failing tire revetment, a tidally influenced backchannel, and a fish-impassable tributary culvert just upstream of the park. This project will pursue removal of the tire revetment, turning the backchannel into a side channel, and making the culvert fish-passable.	Natural resource protection		King County	
North Fork Newaukum Creek near 284th Avenue SE (FPS-2089) — Remove fish barrier culvert and restore stream to natural process and improve conveyance.	Natural resource protection		King County	
Little Soos Creek Fish Passage Project at SE 240th Street (FPS-1997) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection		King County	
Watercress Creek Fish Passage Project at SE 432nd (FPS-2123) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection		King County	
Unnamed Tributary to Big Soos Creek Fish Passage Project at 156th SE & SE 240th (FPS-101, -2604, -1771) — Fish passage project to replace three barrier culverts with two fish-passable structures.	Natural resource protection		King County	
Unnamed Tributary to Covington Creek Culvert Replacement at Thomas Road SE (FPS-2129) — Replace a failing culvert with a fish-passable structure.	Natural resource protection		King County	
NE Auburn Creek Restoration — Enhance tributary confluence with Green River and create a new side channel, provide stream enhancement on public lands, replace a fish passage barrier, create flood benefits, and improve access to non-natal stream for rearing and flood refuge by juvenile Chinook salmon.	Natural resource protection		King County	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Lower Green-Duwamish Levee Vegetation Guidelines — Update lower Green-Duwamish vegetation management guidelines for maintenance and capital projects developed as part of the lower Green River System-Wide Improvement Framework (SWIF). The purpose of the update is to reflect current levee safety risk management and vegetation management best-practice recommendations from the Corps, experienced with vegetation on levees in California and through Engineering with Nature. The update will also achieve greater alignment with initiatives, such as Clean Water Healthy Habitat and WRIA 9 salmon recovery goals.	Natural resource Protection		King County	
Black River Pump Station Control Building Replacement — Design and build the second phase of renovations to the Black River pump station. Major components include replacement of the control building, replacement of the trash rake system, and replacement of the screen spray system.	Structural projects		King County FCD	
Black River Pump Station Fish Passage Improvements — Design and build the fourth phase of renovations to the Black River pump station, revising and replacing the obsolete fish passage systems.	Structural projects		King County FCD	
Black River Pump Station High-Use Engines — Design and build the first phase of renovations to the Black River pump station, replacing the three smaller pump engines that run much more frequently than the other, larger pump engines.	Structural projects		King County FCD	
Black River Pump Station Large Engine Replacement — Design and replace the large engines and overhaul the large pumps at the Black River pump station.	Structural projects		King County FCD	
Black River Pump Station Seismic Upgrades — Strengthen and improve the structure and subsurface soils at the Black River Pump Station.	Structural projects		King County FCD	
Black River Pump Station Support System Upgrades — Design and build the third phase of renovations to the Black River pump station, replacing support systems such as engine control panels, cooling systems, oilers, and hoists.	Structural projects		King County FCD	
Desimone Levee Major Repair (Corps of Engineers) — Design and construct a floodwall to design elevation for 18,800 cfs plus 3 feet of freeboard, repairing slope failures, laying the levee embankment slope back, and shifting the levee alignment (and trail) landward where possible. The floodwall will connect previously constructed floodwalls at Desimone reaches 1 and 2.	Structural projects		King County FCD	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Fort Dent Levee 2020 Repair — Repair several damaged sections of the Fort Dent Levee at approximately River Mile 11 and construct riparian habitat improvements.	Structural projects		King County FCD	
Green River Improvement 2024 — Improve SE Green Valley Road near SE Auburn Black Diamond Road and alleviate roadway flooding by raising the road through the application of a thick layer of overlay.	Structural projects		King County FCD	
Horseshoe Bend Breda Levee Setback Kent — Reconstruct the Horseshoe Bend Levee at the Breda reach (River Mile 24.46–24.72) to a more stable configuration to reduce flood risk to the surrounding areas. The project will also raise levee crest elevations to contain the 0.2 percent annual chance flood, plus 3 feet of freeboard.	Structural projects		King County FCD	
Horseshoe Bend McCoy Realignment Kent — This Corps repair project replaces the SWIF capital project originally planned by the FCD. The repair project is anticipated to stabilize the failure of the levee slope, construct a ring levee around an isolated utility, and shift the alignment of the federal levee back to the City of Kent's secondary containment levee	Structural projects		King County FCD	
Kent Airport Revetment 2022 Repair — Repair project to stabilize the over-steepened bank and rock revetment that has been undercut by rotational bank failure.	Structural projects		King County FCD	
O'Connell Revetment 2021 Repair — Stabilize the O'Connell revetment slope and move or replace the road shoulder and guardrail. Property acquisition for floodplain restoration.	Structural projects		King County FCD	
Signature Point Levee/Floodwall — Provide an increased level of protection to 18,800 cfs (0.2 percent annual chance flood) plus 3 feet of freeboard containment to 1.5 miles of the lower Green River corridor. Modify the Signature Pointe Levee to tie into the recently constructed Hawley Road Levee on the upstream end and the Meyers Golf Levee on the downstream end.	Structural projects		King County FCD	
Tukwila 205 Gunter Floodwall — Construct a flood facility to bring the Gunter segment of the Tukwila 205 Levee into compliance with certification requirements for structural stability and raise the levee to roughly the 0.2 percent annual chance flood event.	Structural projects		King County FCD	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Tukwila 205 Levee Ratolo Segment Floodwall — Construct a 0.15-mile floodwall and sloped embankment to protect adjacent businesses from flooding. The floodwall alignment (including embankment slope, factors of safety, and necessary real estate) will be finalized during the project design phase.	Structural projects		King County FCD	
Tukwila 205 Levee Corps (Gaco Western) Segment Repair — This is a Corps-led project to replace 3,500 feet of Tukwila 205 Levee in-place to bring up to 0.2 percent annual chance flood level of protection.	Structural projects		King County FCD	
S Langston at 125th Drainage Improvement and Flood Risk Reduction — The existing drainage system along S Langston Road and 61st Place S is poorly functioning and results in chronic flooding on public roads and private property, which damages property. This project will upgrade or replace the stormwater conveyance pipes to improve drainage issues and alleviate flooding impacts.	Structural projects		King County FCD	
South Park Conveyance — Construction of drainage improvements in the South Park neighborhood. This work is intended to accelerate implementation of already-planned infrastructure improvements in the South Park neighborhood.	Structural projects		Seattle Public Utilities	
Little Soos Wingfield — Multi-benefit project to restore instream and floodplain habitat through reconnecting the creek to its floodplain, restoring side channels, removing artificial armoring, adding large wood, and revegetating the riparian zone.	Natural resource protection		WRIA 9	
P-17 Pond Levee Setback Feasibility Study — Study opportunity to increase flood storage, improve off-channel habitat, and upgrade the facility to 0.2 percent annual chance flood protection.	Structural projects		City of Tukwila	
S 104th Street Setback Feasibility Study — Analyze over-steepened revetment and opportunity to setback facility to create habitat and increase flood storage.	Natural resource protection; structural		City of Tukwila	
Duwamish Hill Preserve Phase III Design — Study potential to setback road or regrade shoreline to improve habitat and flood storage.	Natural resource protection; structural		City of Tukwila	
S 180th Pump Station Upgrade — Study restoring the full pump capacity that was previously lost to provide increased flood protection.	Structural projects		City of Tukwila	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Duwamish River Sea Level Rise Adaptation (2030-2040) — Planning project to define the preferred design for infrastructure to mitigate sea level rise-related tidal flooding in South Park and Georgetown.	Structural projects		City of Seattle	
Cristy Creek Fish Passage Project at 249th Avenue SE (FPS-3136) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection		King County	
Jenkins Creek Fish Passage Project at Kent-Black Diamond Road SE (FPS-2110) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection		King County	
North Green River Park Floodplain Reconnection – Remove fish passage barrier at an existing flapgate and reconnect floodplain to increase off-channel rearing habitat for juvenile salmon.	Natural resource protection; structural		King County	
Newaukum Creek Fish Passage Project at SE 400th (FPS-1995) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection		King County	
Unnamed Tributaries to Newaukum Creek Fish Passage Projects at SE 424th (FPS-365), 228th SE (FPS-374), 216th SE (FPS-912) — Fish passage projects to replace three barrier culverts with fish-passable structures.	Natural resource protection		King County	
Longfellow Flood Storage Project — Evaluate sites along Longfellow Creek for expanding and restoring the floodplain to increase the flood storage within Longfellow Creek.	Natural resource protection		Seattle Public Utilities	
Tukwila 205 Capital Improvements — Design and implement improvements to the entirety of the 4.3-mile-long Tukwila 205 Levee system to increase design containment 18,800 cfs (0.2 percent annual chance flood) plus 3 feet of freeboard. Involves improving several different segments of the levee system.	Structural projects		City of Tukwila	(or undetermined)

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Berrydale Overcrossing Bridge #3086OX Replacement and Corridor Improvements –This project replaces a fish barrier culvert at Jenkins Creek within the project corridor. This will improve the performance of the culvert and reduce the risks of neighborhood flooding.	Natural resource protection; structural		King County	(or undetermined)
Green River Pre-Construction Strategic Acquisition — Acquire land necessary for planned King County Flood Control District projects and programs in the Green River basin, as it becomes available.	Property protection		King County FCD	(or undetermined)

Vashon-Maury Island and Puget Sound Nearshore

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Dockton Seawall Periodic Repair — The Dockton Road timber seawall on Vashon Island was originally built in 1916, and much of the seawall has failed. Storm surges often damage the low-elevation seawall, and breaches to the wall cause shoulder and roadway erosion. There have been 15 repairs over the last 20 years, primarily to repair sinkholes but larger repair projects are also needed to rebuild the road base and seawall itself.	Structural projects		King County	
McSorley Creek — Restore habitat on the lower 450 feet of McSorley Creek and 1,000 feet of nearshore at Saltwater State Park. Remove shoreline and stream bank armoring that was placed in the 1950s. A portion of the parking lot will be excavated to create a pocket estuary. The project goal is to restore salmon and forage fish habitat and natural habitat-forming processes, while making the park more sustainable in the face of sea level rise.	Natural resource protection		WRIA 9	
Des Moines Creek Restoration — Remove approximately 500 feet of hard shoreline armor and pull back fill material to create a more natural shoreline and stream transition to benefit numerous salmon species.	Natural resource protection		WRIA 9	
California Avenue SW Culvert Replacement — Replace existing culvert with a fish-passable structure and improve the creek channel upstream and downstream of the culvert.	Natural resource protection		Seattle Public Utilities	

White River Watershed

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Unnamed Tributary to Hylebos Creek Culvert Replacement at 370th SE (FPS-2124) — Replace a failing culvert with a fish-passable structure.	Structural projects		King County	
Charlie Jones Creek Fish Passage Project at 176th Avenue SE (FPS-1814, -1815) — Fish passage project to replace two barrier culverts at a road intersection with one fish-passable structure.	Natural resource protection		King County FCD	
212th Avenue SE at State Route 164 Flood Reduction — Improve the existing drainage system to reduce flooding, which may require off right-of-way improvements.	Structural projects		King County FCD	
Charlie Jones Downstream Culvert Repair — Prepare a Concept Development Report to analyze culvert replacement and road-raising options. identify the preferred option(s), analyze upstream and downstream retention/detention impacts, and implement the project.	Structural projects		King County FCD	
Charlie Jones Upstream Culvert Repair — Prepare a Concept Development Report to analyze culvert replacement and road-raising options, identify the preferred option(s), and analyze upstream and downstream retention/detention impacts, and implement the project.	Structural projects		King County FCD	
White River Capital Investment Strategy – Identify and prioritize near-, mid-, and long-term capital projects for FCD funding along the White River.	Structural projects		King County FCD	
Unnamed Tributaries to the White River Fish Passage Projects at SE 472nd (FPS-106), 196th SE (FPS-762), and SE Mud Mtn. Dam Road (FPS-2644) — Fish passage projects to replace three barrier culverts with fish-passable structures.	Natural resource protection		King County	
Seconds Creek Fish Passage Project at 196th Avenue SE (FPS-2286) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection		King County	
Pussyfoot Creek Fish Passage Projects at 180th SE (FPS-1754), 196th SE (FPS-2499), & 212th SE (FPS-158) — Fish passage projects to replace three existing barrier culverts with a fish-passable structure at each location.	Natural resource protection		King County	

Activity Name and Description	Mitigation Category	Types of Flooding Addressed	Source/Origin of Activity	Timeline
Pacific Right Bank Levee Setback — Acquire at-risk, flood-prone residential properties along the right bank of the White River within the City of Pacific to allow for the construction of a new levee setback flood protection structure. Acquired residential structures will be removed, temporary sand-filled flood protection barriers will be removed, artificial fill will be excavated, existing wetland areas will be enhanced, and an earthen setback levee will be constructed. A former dumpsite under Pacific Park will be cleaned up and contamination contained. A pump station will replace the existing undersized mobile pump on Government Canal.	Natural resource protection		King County FCD	
212th Avenue SE at State Route 164 Flood Improvement – The area of 212th Avenue SE at State Route 164 experiences chronic flooding of public and private property. To alleviate neighborhood flooding, the project will improve the drainage system. Conduct a study to determine the source of the flooding, and the project will then design appropriate solutions; project may require off right-of-way improvements.	Structural projects		King County	 (or undetermined)

4.6 King County Action Plan

The King County Action Plan (Action Plan) is a sub-section of the Comprehensive Risk Mitigation Strategy. The Action Plan consists only of activities that King County is committed to funding, reporting on, and implementing within the life of the Flood Plan. The activities in the Action Plan reflect the goals, objectives, and guiding principles that are the foundation of this Flood Plan. The activities chosen for the Action Plan include initiatives with a proven history of success in reducing flood risk and new activities that will help to better address flood risk moving forward.

Programmatic Recommendations

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Emergency Alert and Warning — Maintain the KCInform and Alert and notification system to provide real-time, critical, life-saving emergency messages to county staff, city jurisdictions, and the public.	Emergency services	King County Office of Emergency Management	Emergency Management operating budget		
Emergency Coordination — King County OEM is the coordinating entity for county government during emergency operations in all of the five mission areas (Prevention, Protection, Response, Recovery, and Mitigation). The various county departments and other partners provide capabilities to meet the needs of the operation. During Response operations, King County Office of Emergency Management (OEM), through the Emergency Operations Center (EOC), coordinates and facilitates operations activities, especially when they involve more than one county agency or more than one jurisdiction, are complex in scope or have a unique nature, or in other situations at the request of the departments and partners. Primary roles of the King County OEM include resource management and supporting situational awareness.	Emergency services	King County Office of Emergency Management	Emergency Management operating budget		
Emergency Public Information — Facilitate local and regional message coordination. Manage the King County Emergency Management Blog to share public information messages with partners. Coordinate cross-jurisdictional, cross-discipline public information / communicators group for message collaboration.	Emergency services	King County Office of Emergency Management	Emergency Management operating budget		
Regional Coordination — Facilitate regional coordination of emergency management activities with county agencies, other jurisdictions, and the private sector to support information sharing and other activities, as well as lend support to minor issues. This coordination is scalable from routine operations to regional coordination, or enhanced operations for specific threats, incidents, or special events.	Emergency services	King County Office of Emergency Management	Emergency management budget Grants		
Regional Flooding Exercise — Conduct annual regional flooding exercises to include multiple agencies with flood response capability, and complete an evaluations, and create a lessons- learned report to be submitted annually to CRS.	Emergency services	King County Office of Emergency Management	Emergency management budget Grants		
Headwaters and Floodplain Acquisition and Protection — Continue annual fee and easement acquisition of natural lands, providing preventive and natural resource protection benefits. Projects occur countywide and can occur either in upland areas that add recreational and watershed function benefits or in floodplain or adjacent environments that prioritize ecological restoration and salmon recovery.	Natural resource protection	King County Parks King County Water and Land Resources	Conservation Futures Program King County Parks Levy Various federal, state, and local grants		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
King County Road Alerts — Provide email and text alert services for road conditions in unincorporated King County, including weather- and flood-related road closures and natural disasters. Alerts are also posted on X (formerly Twitter).	Emergency services	King County Roads	Roads Operating Budget		
My Commute Website/Map — Provide public travel alerts on a web map with road closures and restrictions, including flooding or landslides. Users can select each reported location to see more information on cause and anticipated duration of closures/restrictions. Users can also access the images from traffic cameras located across the county to view road conditions in real time. Most of the information is for County-managed roads in the unincorporated area, but some information is also provided by other agencies, such as WSDOT.	Emergency services	King County Roads	Roads Operating Budget		
Post- Flooding Bridge Inspection — Following high-flow events, perform safety inspections on a select set of bridges, looking for scour, road overtopping, and debris buildup in the most impacted flooded areas.	Emergency services	King County Roads	Roads Operating Budget		
Roads 24/7 Helpline — The helpline is staffed with customer service agents to perform call intake of county road issues, including storm safety and flooding related incidents.	Emergency services	King County Roads	Roads Operating Budget		
Road Drainage System Preventive Maintenance — Perform annual catch- basin inspection and cleaning to ensure drainage systems remain unclogged and functional. Also includes cleaning drainage ditches, mowing, and litter and debris removal.	Prevention	King County Roads	King County Roads Operating Budget		
Road Drainage Preservation Program – This program identifies, prioritizes, and improves roadway drainage infrastructure related to surface water, groundwater, and stormwater runoff. Improvements aim to reduce flooding and mitigate property damage.	Prevention	King County Roads	King County Roads Capital Budget SWM Funds		
Road Drainage System Reactive Maintenance — Resolve stream, ditch, or drainage system clogs within the road right-of-way.	Prevention	King County Roads	King County Roads Operating Budget		

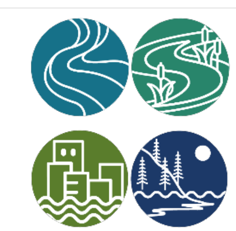
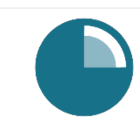
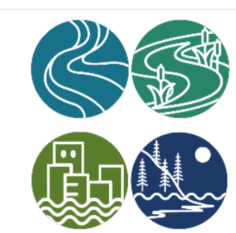
Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Stormwater Emergency Response — Provide emergency response services to emergent situations in which flooding, erosion, or pollution in or along the stormwater drainage system is causing or imminently threatens to cause a severe hazard to public safety, public health, or aquatic life. The stormwater drainage system includes both natural and manmade features that convey, store, infiltrate, or otherwise manage stormwater runoff in unincorporated King County.	Emergency services	King County Water and Land Resources	King County Surface Water Management		
Provide translated educational materials and emergency information, including King County agency contacts, during times of emergency.	Emergency services	King County Water and Land Resources King County Office of Emergency Management	Grants		
Landslide Hazard Mapping — Expand the County's understanding of landslide risk areas through updating maps as information changes and use the information to inform the development of appropriate mitigation solutions where coastal flood hazards and landslide hazards intersect.	Prevention	King County Water and Land Resources	King County Surface Water Management Grants		
Collaborate with jurisdictions to identify differences in municipal flood hazard area regulations within King County, identify implications for achieving plan outcomes, and **provide technical assistance to jurisdictions** within King County to support strengthening local regulations where they are deemed beneficial.	Prevention	King County Water and Land Resources	King County Surface Water Management		
Land Conservation Acquisitions — Acquire open space for conservation and protection, and to secure footprints necessary for floodplain restoration projects and stormwater retrofit projects.	Prevention	King County Water and Land Resources	Various state and local grants		
Pursue opportunities to support stormwater retrofit projects as part of scoping and designing flood risk reduction projects.	Prevention	King County Water and Land Resources	King County Surface Water Management Various state and local grants		
Drainage Enforcement Program — Enforce the requirements of the *Surface Water Design Manual*, including the attenuation of runoff from developed surfaces that would otherwise increase flood flows.	Prevention	King County Water and Land Resources	King County Surface Water Management		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Landslide Hazard Mapping — Expand the County's understanding of landslide risk areas through updating maps as information changes and use the information to inform the development of appropriate mitigation solutions where coastal flood hazards and landslide hazards intersect.	Prevention	King County Water and Land Resources	King County Surface Water Management Grants		
Collaborate with jurisdictions to identify differences in municipal flood hazard area regulations within King County, identify implications for achieving plan outcomes, and **provide technical assistance to jurisdictions** within King County to support strengthening local regulations where they are deemed beneficial.	Prevention	King County Water and Land Resources	King County Surface Water Management		
Protect headwaters of tributary streams that may be sensitive to climate change to alleviate flashy flows and mitigate downstream flood risk.	Prevention	King County Water and Land Resources King County Parks	King County Parks Levy Various state and local grants		
Land Conservation Acquisitions — Acquire open space for conservation, and protection, and to secure footprints necessary for floodplain restoration projects and stormwater retrofit projects.	Prevention	King County Water and Land Resources	Various state and local grants		
Pursue opportunities to support stormwater retrofit projects as part of scoping and designing flood risk reduction projects.	Prevention	King County Water and Land Resources	King County Surface Water Management Various state and local grants		
Drainage Enforcement Program — Enforce the requirements of the *Surface Water Design Manual*, including the attenuation of runoff from developed surfaces that would otherwise increase flood flows.	Prevention	King County Water and Land Resources	King County Surface Water Management		
Provide technical assistance to low-income property owners so they can secure the funding needed to implement an elevation.	Property protection	King County Water and Land Resources	Various federal and local grants		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Encourage the purchase of flood insurance and collaboratively work with partners to design a social marketing campaign or other similar effort with a goal of increasing flood insurance policies held in King County.	Property protection	King County Water and Land Resources	King County Surface Water Management Grants		
Agricultural Drainage Assistance Program (ADAP) — Provide technical and financial support to agricultural property owners to improve drainage of agricultural lands.	Public information	King County Water and Land Resources	King County Surface Water Management		
Stormwater Complaint Program — Field drainage complaints, and determine whether a King County program or interest should be involved with a resolution, and provide public information.	Public information	King County Water and Land Resources	King County Surface Water Management		
Stormwater Engineer Review Program — Address flooding and drainage complaints requiring a deeper level of analysis than provided by the complaint program. Determine whether a King County program or interest should be involved with a resolution and/or provide technical assistance to private landowners.	Public information	King County Water and Land Resources	King County Surface Water Management		
Stormwater Engineer Studies Program — Address flooding and drainage complaints requiring a deeper level of analysis or with a greater breadth of scope than is provided by the Engineer Review program. Determine whether a King County program or interest should be involved with a resolution and/or provides technical assistance to private landowners.	Public information	King County Water and Land Resources	King County Surface Water Management		
Neighborhood Drainage Assistance Program (NDAP) — Resolve stormwater-related flooding, erosion, and sedimentation problems in unincorporated King County by designing and building new drainage systems, repairing existing drainage systems, or providing technical assistance, with a focus on projects that maximize benefit to the County's stormwater system.	Structural	King County Water and Land Resources	King County Surface Water Management		
Ensure that **management and stewardship of lands** acquired for flood mitigation or multi-benefit purposes **aligns with King County guidance related to encampment procedures and protocols**.	Property protection	King County Water and Land Resources King County Parks	Custodial agency		
Evaluate the status of King County's River Facility Inventory to identify facilities that no longer serve a functional purpose and develop a project portfolio for obsolete facility removal and site restoration.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management Grants		
Provide Accessible Customer Support Information —King County's exemplary floodplain regulations are complex, and permitting delays or errors can be caused by customers not understanding the purpose behind the code or permit and submittal requirements.	Prevention	King County Department of Local Services	Permit fees		
Hazard Mitigation Plan Update — Maintain the King County Regional Hazard Mitigation Plan and support development of mitigation strategies aimed at reducing risk. Provide technical assistance with planning efforts and grants to mitigate flood risk.	Emergency services	King County Office of Emergency Management	Federal grants		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
All Hazard Public Education Program — Provide preparedness education to the public (unincorporated King County) as well as support hazard education with local jurisdictions.	Emergency services	King County Office of Emergency Management	Various federal grants		
Risk Reduction Support via Grants — Provide coordination and support to agencies and jurisdictions pursuing grants to mitigate flood-related risks (such as BRIC, HMA, FMA, HHDMG).	Public information	King County Office of Emergency Management	Various federal grants		
Dam Safety Education Program — Provide information to communities, businesses, and jurisdictions about dam hazards. Coordinate with dam owners and operators on dam safety protocols and response activities. Work with dam owners and operators of High Hazard Dams to look at opportunities for improvements. Assist with developing grant applications for dam mitigation work.	Public information	King County Office of Emergency Management	Emergency management budget Various federal, state, and local grants		
Open Space - River Corridors Grants — Provide annual funding to support projects that restore the natural functions of rivers, create or restore public access, and/or increase public awareness of river corridors as valuable natural resources. This program incentivizes multi-benefit projects that integrate recreation and habitat restoration with larger floodplain management efforts.	Natural resource protection	King County Parks	King County Parks Levy		
King County Integrated Drainage Program (IDP) Pilot — Provide expanded drainage services to rural King County landowners in the non-built (i.e., natural) environment using a multi-objective approach to provide drainage improvements, mitigate local flood hazards, and enhance fish passage and aquatic and riparian habitats.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management		
Examine ways to improve the communication of flood warning information to the public, including updating flood phase thresholds and identifying ways to provide flood warning messages to vulnerable populations and those experiencing homelessness who live in at-risk areas.	Emergency services	King County Water and Land Resources	Grants		
Identify mechanisms to **improve cross-agency emergency response coordination**.	Emergency services	King County Water and Land Resources King County Office of Emergency Management	Grants		
Identify and implement **wetland restoration and protection activities** to mitigate flood risk.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management King County Mitigation Reserves Program Various state and local grants		
Review and update King County's procedures related to naturally occurring large wood in rivers and streams via coordination among King County DNRP, the King County Sheriff's Office, and other agencies as necessary. Activities should be consistent with the policies and other recommendations outlined in this Flood Plan, including the recognition that wood is an integral element of aquatic habitat necessary for ESA-listed salmon and moving wood incurs significant mitigation expense.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Review and update King County Public Rule LUD 12-1 (effective April 30, 2010), which addresses procedures for considering public safety in development and design of capital projects that include placement of wood in rivers and streams of King County.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management		
Work with farmers to **implement riparian buffers, native plantings, and flood resilience measures on agricultural lands** in the floodplains.	Natural resource protection	King County Water and Land Resources	Conservation Reserve Enhancement Program (CREP) State and local grants		
Analyze and map alluvial fan hazard areas.	Prevention	King County Water and Land Resources	King County Surface Water Management Various state and local grants		
Coastal Flooding Best Practices — Evaluate best practices from other states for coastal flood mitigation and identify options that could be applied locally.	Prevention	King County Water and Land Resources	King County Surface Water Management Grants		
Comprehensive Residential Mitigation Feasibility Study — Update and expand the County's Repetitive Loss Area Analysis to conduct a study of all unincorporated areas to assess flood vulnerability of residential structures and recommend mitigation actions.	Prevention	King County Water and Land Resources	King County Surface Water Management Grants		
Develop alluvial fan hazard regulations.	Prevention	King County Water and Land Resources King County Department of Local Services	King County Surface Water Management		
Update King County's Flood Hazard Code to ensure continued protection of life and safety, FEMA compliance, and continued exceedance of NFIP minimum standards while also recognizing the value of flood hazard areas as critical habitat for ESA-listed species and allowing for efficient and effective restoration of natural floodplain functions and culvert replacements to restore fish passage.	Prevention	King County Water and Land Resources King County Department of Local Services	King County Surface Water Management		
Evaluate opportunities for regulatory flexibility for flood resilience upgrades to structures that do not conflict with the County's NFIP standing.	Prevention	King County Water and Land Resources	King County Surface Water Management		
Equity Performance Measures and Monitoring — Develop performance measures for floodplain management equity outcomes and incorporate them into King County monitoring activities.	Prevention	King County Water and Land Resources	Grants		
Promote King County's home elevation program, explore partnership opportunities to **expand the program** to all flood hazard areas where conditions are favorable for elevations, and **provide technical assistance** to property owners to understand feasibility and funding options for home elevation. **Expand and advertise King County's home elevation program** to all flood hazard areas where conditions are favorable for elevations.	Property protection	King County Water and Land Resources	Various federal, state, and local grants Partnerships and grants		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Home Elevation Educational Materials – Create educational materials and technical assistance to help homeowners understand the feasibility and funding options for home elevation.	Property protection	King County Water and Land Resources	Various federal, state, and local grants		
Develop a pre-acquisition process for evaluating factors, such as the equity implications and cultural interests affected by a potential acquisition and the effects to neighborhoods and communities of converting private property to public open space. Incorporate geospatial decision support tool to be developed as part of recommendation under structural projects for advancing multi-benefit projects.	Property protection	King County Water and Land Resources King County Parks	King County Surface Water Management King County Parks Levy		
Evaluate whether stormwater retrofits or other resilience improvements could provide effective flood risk reduction in lieu of acquisition in areas that are not ecologically significant or not connected to a capital project need.	Property protection	King County Water and Land Resources	King County Surface Water Management		
Improve Access to Flood Preparedness Materials – Collaboratively engage diverse audiences to co-create effective flood preparedness outreach. This may require different graphics, address broader topics, and use different methodologies to meaningfully reach different cultures and communities. Also, identify tools and implement preparedness outreach to those experiencing homelessness who live in at-risk areas, specifically riparian areas.	Public information	King County Water and Land Resources	Grants King County Surface Water Management		
Develop a program for public information to connect floodplain managers and partners to collaboratively create and implement more targeted outreach to change behavior when building more resilient communities.	Public information	King County Water and Land Resources	Grants King County Surface Water Management		
Analyze the feasibility of map information improvements that would produce interactive web-based mapping tools to show inundation areas and flood depths at various modeled high-flow conditions on major rivers using existing information and models already available to the public, such as those used for FEMA's Flood Insurance Rate Map studies and reports.	Public information	King County Water and Land Resources	Grants King County Surface Water Management		
Develop and provide information about permitting requirements and potential strategies related to home resilience. Improved technical services are an investment that would provide more readily available information so builders, property owners, and renters could understand flood hazard- related regulations and more successfully evaluate the building of flood-safe structures.	Public information	King County Water and Land Resources King County Department of Local Services	King County Surface Water Management Other county funds		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Beaver Education — Provide educational information about the role of beavers in the Pacific Northwest and provide landowners with beaver management resources, management tools, and technical expertise to limit flooding and property damage from beaver activity.	Public information	King County Water and Land Resources	King County Surface Water Management		
Flood Resilience Improvement Program — Develop a comprehensive program to raise awareness about flooding, increase flood preparedness, reduce flooding impacts, and increase community resilience. Engage with communities and community-based organizations to identify their needs in building flood resilience and provide support to achieve their flood resilience goals.	Public information	King County Water and Land Resources	Grants		
Stormwater Education Program — This outreach program is designed to educate landowners about the importance of stormwater controls, including flow control, which contributes to reductions in downstream flooding.	Public information	King County Water and Land Resources	King County Surface Water Management		
Tidal/Riverine Flooding Connections — Provide resources about the interdependencies among riverine, tidal, and coastal influences on flooding, including potential impacts and roles and responsibilities for preparedness and response.	Public information	King County Water and Land Resources	King County Surface Water Management Various federal, state, and local grants		
Update the King County *Water and Land Resources Project Management Manual* to include multi-benefit considerations early in the project development process (no later than alternatives analysis) so that multi-benefit opportunities are identified and considered across all projects.	Structural	King County Water and Land Resources	King County Surface Water Management		
River Facility Inventory Asset Management System – Update the river facility inventory of levees and revetments in King County to a geospatial asset management system.	Structural	King County Water and Land Resources	Grants King County Surface Water Management		
Develop a geospatial project decision-support tool to inform the development of projects that will advance multi-benefit outcomes, including layers that identify different program priorities for acquisitions and capital projects.	Structural; property protection	King County Water and Land Resources	King County Surface Water Management		
Use projections of changes in future river flows **to study potential changes in river or basin-scale risks from climate change** to inform appropriate risk reduction and resilience actions.	Prevention	King County	Grants		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Managed Retreat Planning — Identify high-risk neighborhoods where managed retreat may be preferred or necessary, including retreat from severe channel migration zones.	Property protection	King County Water and Land Resources	King County Surface Water Management Various federal, state, and local grants		
Improve Road Safety in Flood-Prone Areas — Assess opportunities to improve flood-safe road access, map current and possible evacuation routes, and explore feasibility of priority resilient evacuation road projects.	Structural	King County Roads	Grants		(or undetermined)
Support property owners with resources for **on-site flood response action plans and other short-term response tools**.	Emergency services	King County Water and Land Resources King County Office of Emergency Management	Grants		(or undetermined)

Capital Project Recommendations

South Fork Skykomish/Snoqualmie River Watershed

South Fork Skykomish River

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Lower Miller River Floodplain Restoration Project — Restore up to 140 acres and several miles of Miller River mainstem and tributary and side-channel habitat to improve salmonid habitat in the South Fork Skykomish watershed.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management Various state and local grants		

Upper Snoqualmie River

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
SE Reinig Road Drainage Improvement Culvert — The existing culvert on SE Reinig Road near North Fork Road SE is inadequately sized, which restricts water flow and causes annual flooding on nearby roadways and private properties. This project will replace the 40-inch-diameter corrugated metal pipe to increase water flow and provide fish passage.	Natural resource protection; structural	King County Roads	Real Estate Excise Tax Local grants		
North Fork Bridge #1221 Replacement (Roads CIP #1143969) — Bridge replacement project to reduce the frequency of road flooding and subsequent neighborhood isolation by raising the height of 428th Avenue SE and increasing the hydraulic opening of the bridge.	Structural projects	King County Roads	Real Estate Excise Tax Federal, state, or local grants		

Lower Snoqualmie River

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Mouth of Tuck Creek Fish Passage Project (FPS-1671) — Fish passage project to replace one barrier culvert, floodgate, and fishway with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources	King County Surface Water Management Various federal, state, and local grants		
Daniels Creek Fish Passage Projects at NE 185th (FPS-408) and NE Woodinville-Duvall Road (FPS-170) — Fish passage projects to replace two existing barrier culverts with fish-passable structures at both locations.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Federal, state, and local grants		
Langlois Creek Fish Passage Project at NE 24th Street (FPS-2130) — Fish passage project to replace one barrier culvert at a road intersection with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Local grants		
Tributary to Horseshoe Lake at Snoqualmie Valley Trail just North of NE Carnation Farm Road (FPS-2373) — Replace existing concrete culvert to improve fish passage and conveyance.	Natural resource protection; structural	King County Parks	Real Estate Excise Tax 2 Local grants		
Ames Creek Fish Passage Projects at NE 100th (FPS-1757) and NE 80th (FPS-565) — Fish passage projects to replace two existing barrier culverts with a fish-passable structure at both locations.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Various federal, state, local grants		
Mouths of Unnamed Tributaries to the Snoqualmie River at W Snoqualmie River Road (FPS-2528 & -2529) — Fish passage projects to replace three barrier culverts/flood gates with fish-passable structures.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management State and local grants		
Harris Creek Fish Passage Projects on NE Stossel Creek Way (FPS-2176, -157, -638, -5670) — Fish passage projects to replace four existing barrier culverts with fish-passable structures.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Federal, state, and local grants		
334th Avenue SE and SE 43rd Place Flood Improvement — The area of 334th Avenue SE and SE 43rd Place experiences chronic flooding of public and private property. This project is designed to alleviate neighborhood flooding by constructing a drainage system to flow to the Snoqualmie River.	Structural projects	King County Roads	Various federal, state, and local grants		
Snoqualmie River Farm Floodplain Reconnection — Explore ways to reconnect Snoqualmie River floodplain to improve salmon habitat while also protecting farmland and farm structures at the Snoqualmie River Farm (formerly Beyers property) with a feasibility study and project design.	Natural resource protection	King County Water and Land Resources	Various federal, state, and local grants		(or undetermined)

Lake Washington/Cedar/Sammamish River Watershed

Cedar River Basin

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Cedar River Lower Rutledge-Johnson Floodplain Restoration — Multi-benefit floodplain restoration project adjacent to State Route 169 and Cedar River Trail.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management State and local grants		
Molasses Creek Barrier Removal Project — A fish passage project that will remove a fish passage barrier at the mouth of Molasses Creek.	Natural resource protection	King County Water and Land Resources King County Roads	King County Surface Water Management		
Molasses Creek Culvert Replacement Project at SE Petrovitsky and 134th SE (FPS-1602, -650) — Replace two failing culverts with two fish-passable structures.	Natural resource protection; structural	King County Roads	Real Estate Excise Tax Federal, state, and local grants		
WPA Levee Setback – Remove and set back the WPA Levee along the Cedar River. This project would reconnect floodplain habitat and could reduce erosion risk to the downstream Belmondo Levee.	Natural resource protection; structural	King County Water and Land Resources	King County Surface Water Management State and local grants		(or undetermined)
SE Petrovitsky Road at 151st Avenue SE – The culvert under SE Petrovitsky Road and 151st Avenue SE is failing, and the road is at risk of collapsing. Due to the failed pipe, the outlet often plugs and water overtops SE Petrovitsky Road. This project will replace the culvert and add a new inlet structure with a debris cage to prevent the system from plugging. This will also improve outfall from the nearby detention facility.	Structural projects	King County Roads	King County Surface Water Management Roads Capital Budget		(or undetermined)

Sammamish River/Lake Sammamish Basin

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Peters Creek at WSRT north of NE 90th Street (FPS-941, CLO-132509) — Replace 72-inch-diameter deteriorating metal pipe with fish-passable structure. Improved conveyance.	Natural resource protection; structural	King County Parks	Real Estate Excise Tax 2		
Trib to Sammamish River at Marymoor Dog Park (FPS-1257, CLO-114463 & FPS-1258, CLO-147289) — Replace two deteriorating culverts with fish-passable structures. Improved conveyance.	Natural resource protection; structural	King County Parks	Real Estate Excise Tax 2		
Trib to Sammamish River at SRT near NE 143rd Street (FPS-2076, CLO-130643) — Replace existing 24-inch-diameter corroded bottom barrel of culvert with fish-passable structure. Improved conveyance.	Natural resource protection; structural	King County Parks	Real Estate Excise Tax 2		
Bear Creek Integrated Restoration and Stormwater Projects — Integrated planning and implementation of habitat restoration and stormwater retrofit projects.	Natural resource protection; structural	King County Water and Land Resources	King County Surface Water Management State and local grants		
Daniels Creek Fish Passage Projects at NE 185th (FPS-408) and NE Woodinville-Duvall Road (FPS-170) — Fish passage projects to replace two existing barrier culverts with fish-passable structures at both locations.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Federal, state, and local grants		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Cottage Lake Creek Fish Passage Projects at Avondale Road NE (FPS-2098), NE 128th Way (FPS-165), NE 165th (FPS-2296), and NE Avondale & NE 144th (FPS-2099) — Fish passage projects to replace four barrier culverts with fish-passable structures.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Federal, state, and local grants		
Update Lake Sammamish Flood Study — Addresses problematic mapping of homes in and out of the floodplain due to poor-quality elevation data. New high-resolution aerial photos and Light Detection and Ranging (LiDAR) data collected in 2020 and 2021 could produce significantly more accurate mapping.	Preventive	King County	Federal, state, and local grants		
George Davis Creek at ELST (FPS-2142) — Fish passage culvert replacement is part of ELST South Sammamish Phase 2 project.	Natural resource protection; structural	King County Parks	King County Parks Levy		(or undetermined)

Issaquah Creek Basin

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Carey/Holder/Issaquah Creek Confluence Restoration — New project start on former Bonomi farm. Feasibility completed in 2023. Coordinated planning effort between King County's Agriculture, Forestry, and Incentives; Ecological Restoration and Engineering Services; Basin Steward; and Parks kicks off in 2024. Cost assumes 45 acres of restoration and 4,500 linear feet of channel work.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management State and local grants		
Carey Creek Fish Passage Project at 276th SE — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Federal, state, and local grants		
East Fork Issaquah Creek Fish Passage Project at NE High Point Way (FPS-2897) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Federal, state, and local grants		
East Fork Issaquah Creek Floodplain Restoration Strategy —System-wide study of the benefits of restoring a 3-mile section of the creek in unincorporated King County from West Tiger Mountain at SE 88th, downstream to the High Point Way interchange off I-90.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management Federal, state, and local grants		
Fifteen Mile Creek Bridge #493C Replacement — The current bridge carries SE May Valley Road, a major arterial over Fifteen Mile Creek. The original bridge was built in 1932 and is structurally deficient with substandard rails, narrow width, and a poor hydraulic opening. This bridge replacement project will remove the existing bridge, associated fill, and stream bank armoring that is constricting the creek's flow and creating flooding, scour, and potential water-quality issues.	Structural projects	King County Roads	Roads Capital Budget Federal grants		
208th Avenue SE @ SE 135th Culvert — The existing culvert at 208th Avenue SE and SE 135th Street is in an area where alluvial soils and sediment build up and reduce its capacity to carry flows. This causes frequent flooding on a sole-access road. This project will replace the culvert to increase water flow and provide fish passage.	Natural resource protection; structural	King County Roads	Real Estate Excise Tax		

Lake Washington Basin

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Margaret's Way Trailhead Driveway Culvert (FPS-2737) — Replace culvert with fish passage structure. Existing culvert is corroded and undersized, which causes piping around the inlet to form sinkholes. Improved conveyance.	Natural resource protection; structural	King County Parks	Real Estate Excise Tax 2 Local grants		

Green/Duwamish River Watershed

Green/Duwamish River Basin

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Cecil Moses Tire Revetment — Cecil Moses Park features a failing tire revetment, a tidally influenced backchannel, and a fish-impassable tributary culvert just upstream of the park. This project will pursue removal of the tire revetment, turning the backchannel into a side channel and making the culvert fish-passable.	Natural resource protection	King County Water and Land Resources	State and local grants		
NE Auburn Creek Restoration — Enhance tributary confluence with Green River and create a new side channel, provide stream enhancement on public lands, replace a fish passage barrier, flood benefits, and improve access to non-natal stream for rearing and flood refuge by juvenile Chinook.	Natural resource protection	King County Water and Land Resources	King County Surface Water Management State and local grants		
Lower Green-Duwamish Levee Vegetation Guidelines — Update lower Green-Duwamish vegetation management guidelines for maintenance and capital projects developed as part of the lower Green River SWIF. The purpose of the update is to reflect current levee safety risk management and vegetation management best-practice recommendations from the Corps, experienced with vegetation on levees in California and through Engineering with Nature. The update will also achieve greater alignment with initiatives, such as Clean Water Healthy Habitat and WRIA 9 salmon recovery goals.	Natural resource Protection	King County	Federal, state, and local grants		
Little Soos Creek Fish Passage Project at SE 240th Street (FPS-1997) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Various federal, state, and local grants		
Watercress Creek Fish Passage Project at SE 432nd (FPS-2123) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Various federal, state, and local grants		
Unnamed Tributary to Big Soos Creek Fish Passage Project at 156th SE & SE 240th (FPS-101, -2604, -1771) — Fish passage project to replace three barrier culverts with two fish-passable structures.	Natural resource protection; structural	King County Water and Land Resources King County Roads	Real Estate Excise Tax Federal, state, and local grants		
Unnamed Tributary to Covington Creek Culvert Replacement at Thomas Road SE (FPS-2129) — Replace a failing culvert with a fish-passable structure.	Natural resource protection; structural	King County Roads	Real Estate Excise Tax		
North Fork Newaukum Creek near 284th Avenue SE (FPS-2089) — Remove fish barrier culvert and restore stream to natural process and improve conveyance.	Natural resource protection; structural	King County Parks	Real Estate Excise Tax		
North Green River Park Floodplain Reconnection — Remove fish passage barrier at an existing flapgate and reconnect floodplain to increase off-channel rearing habitat for juvenile salmon.	Natural resource protection; structural	King County Water and Land Resources	King County Surface Water Management State and local grants		
Cristy Creek Fish Passage Project at 249th Avenue SE (FPS-3136) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Various federal, state, and local grants		
Jenkins Creek Fish Passage Project at Kent-Black Diamond Road SE (FPS-2110) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Various federal, state, and local grants		
Newaukum Creek Fish Passage Project at SE 400th (FPS-1995) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Various federal, state, and local grants		

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Unnamed Tributaries to Newaukum Creek Fish Passage Projects at SE 424th (FPS-365), 228th SE (FPS-374), and 216th SE (FPS-912) — Fish passage projects to replace three barrier culverts with fish-passable structures.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Various federal, state, and local grants		
Berrydale Overcrossing Bridge #3086OX Replacement and Corridor Improvements – This project replaces a fish barrier culvert at Jenkins Creek within the project corridor. This will improve the performance of the culvert and reduce the risks of neighborhood flooding.	Natural resource protection; structural	King County Roads	Roads capital budget Grants		(or undetermined)

Vashon-Maury Island and Puget Sound Nearshore

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Dockton Seawall Periodic Repair — The Dockton Road timber seawall on Vashon Island was originally built in 1916, and much of the seawall has failed. Storm surges often damage the low-elevation seawall, and breaches to the wall cause shoulder and roadway erosion. There have been 15 repairs over the last 20 years, primarily to repair sinkholes but larger repair projects are also needed to rebuild the road base and seawall itself.	Structural projects	King County Roads	Roads Operating or Capital Budget determined by the type and estimated costs of the repair		

White River Watershed

Activity Name and Description	Mitigation Category	Potential Lead Agency	Potential Funding Source(s)	Types of Flooding Addressed	Timeline
Unnamed Tributary to Hylebos Creek Culvert Replacement at 370th SE (FPS-2124) — Replace a failing culvert with a fish-passable structure.	Natural resource protection; structural	King County Roads	Real Estate Excise Tax Federal, state, and local grants		
Unnamed Tributaries to the White River Fish Passage Projects at SE 472nd (FPS-106), 196th SE (FPS-762), and SE Mud Mtn. Dam Road (FPS-2644) — Fish passage projects to replace three barrier culverts with fish-passable structures.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management State and local grants Real Estate Excise Tax		
Pussyfoot Creek Fish Passage Projects at 180th SE (FPS-1754), 196th SE (FPS-2499), & 212th SE (FPS-158) — Fish passage projects to replace three existing barrier culverts with a fish-passable structure at each location.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Federal, state, and local grants		
Seconds Creek Fish Passage Project at 196th Avenue SE (FPS-2286) — Fish passage project to replace one barrier culvert with a fish-passable structure.	Natural resource protection; structural	King County Water and Land Resources King County Roads	King County Surface Water Management Federal, state, and local grants		
212th Avenue SE at State Route 164 Flood Improvement – The area of 212th Avenue SE at State Route 164 experiences chronic flooding of public and private property. To alleviate neighborhood flooding, the project will improve the drainage system. Conduct a study to determine the source of the flooding, and the project will then design appropriate solutions; project may require off right-of-way improvements.	Structural projects	King County	Federal, state, and local grants		(or undetermined)

CHAPTER 5
Plan Implementation

This 2024 King County Flood Management Plan identifies many activities to enhance the resilience of King County's communities to various flood-related risks, but the Flood Plan is only useful insofar as it is implemented and maintained. Step 10 of the 10-step Community Rating System (CRS) planning process calls for implementing plans and changing course as conditions change or new information becomes available. This chapter describes how King County will implement the Flood Plan and keep the plan current through annual evaluation and describes the expectations for future updates to the plan. The chapter also discusses how to incorporate the Flood Plan into existing planning mechanisms and continue public involvement.

5.1 Plan Implementation

This Flood Plan and its recommendations are based on the premise that flooding in King County is a regional issue and, as such, flood risk reduction and building flood-resilient communities require extensive collaboration and strong partnerships. King County will continue to coordinate and partner with local jurisdictions, special districts, state and federal agencies, tribal governments, and others to collaboratively advance the goals of this Flood Plan. King County will continue to implement activities that reduce flood risk and improve resilience countywide using a variety of funding sources and partnerships.

King County's Role in Implementation

Chapter 4 describes a comprehensive strategy for reducing flood and flood-related risks for multiple floodplain management partners throughout the county. King County's role in implementing these strategies is multifaceted. First, King County functions as a convener to work collaboratively with partners to identify salmon recovery, open space, agriculture, and stormwater projects and programs that often intersect with flood risk reduction (such as through groups like Snoqualmie Fish Farm Flood and the WRIA salmon recovery forums). Second, King County develops, adopts, and implements zoning and land use regulations and manages stormwater and habitat restoration projects and programs within the unincorporated areas of the county. Third, King County develops and adopts the Regional Hazard Mitigation Plan and provides regional parks, wastewater, and road services. King County is the primary contracted service provider to the King County Flood Control District (FCD; see next section below for description) for delivering a wide range of programs and projects to reduce flood risk. As explained elsewhere in this Flood Plan, the FCD is a separate government from King County, with its own revenue stream and decision-making structure.

Many of the activities funded by the FCD are implemented by King County acting as service provider to the FCD.

The Flood Plan is a functional plan of King County's Comprehensive Plan. Once adopted by the County Council, the Flood Plan establishes policy guiding flood risk reduction and floodplain management, including setting the foundation for the County's codes and regulations addressing flood hazard areas. King County will consider any needed code revisions to align with the Flood Plan's recommendations, as well as its goals, objectives, and guiding principles.

As explained in Chapter 4, the activities King County proposes to implement are called out in the King County Action Plan, which is driven by need, feasibility, and funding availability. King County's Water and Land Resources Division (WLRD) in the Department of Natural Resources and Parks is the County's lead agency in implementing many of the County's flood risk reduction services. Other King County divisions and departments lead activities in the realm of emergency operations, maintenance of roads and bridges, implementation and enforcement of land use and building regulations, and park and open space management. WLRD will continue to provide leadership and collaborate with these other departments and divisions to pursue cooperative, interdisciplinary implementation of this Flood Plan and will continue its work to leverage a variety of funding sources.

Partnerships and Existing Authorities Supporting Implementation

This Flood Plan articulates the different types of flooding and flood-related risks that are present in King County, which extend from marine shorelines to the upstream extent of developed landscapes in the Cascades foothills. Flooding takes many forms and occurs in a variety of different landscapes and does not abide by jurisdictional boundaries. A variety of existing institutional structures are in place to address specific aspects of flood-related issues. These include the following:

- **Surface water/stormwater management –** Local governments in King County—including the County and most cities—are required to address stormwater and surface water runoff through the National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit. All cities and counties that implement activities under their municipal stormwater permit collect surface water management fees. Stormwater management programs generally address outreach, maintenance, and capital projects to reduce the impacts of stormwater runoff and flooding. The nature of these programs is that they are perpetual, with variable funding and staffing capacity as determined by locally established surface water management fees. In addition to local governments developing and implementing their own stormwater management programs, regional efforts are underway in Central Puget Sound intended to achieve the best overall outcomes at the watershed scale.
- **Floodplain management –** Many local governments maintain floodplain management programs of some kind to ensure compliance with National Flood Insurance Program (NFIP) standards. This includes maintaining and enforcing land use regulations to prevent

the creation of new risks, communicating about flood preparedness, and providing emergency response services. These roles and authorities are successful for achieving flood risk reduction and building resilient communities yet are often underfunded.

- **King County Flood Control District (FCD) –** The King County FCD was established in 2007 as a special-purpose district following a recommendation from the 2006 King County Flood Hazard Management Plan, with the purpose of addressing a growing list of flood risk reduction and infrastructure maintenance needs. A levy to fund the FCD's priorities became effective in 2008. The FCD has become the most prolific sponsor of flood risk reduction projects and programs across King County, with a focus on mainstem rivers and major tributaries, as well as on maintaining the County's flood protection infrastructure (levees and revetments). King County serves as the primary service provider to implement the FCD's work program. The King County FCD is a separate governmental entity from King County, with its own governance, funding source, and budgetary process. This Flood Plan was developed in consultation with the FCD and includes activities funded in its current publicly available 6-year Capital Improvement Plan (CIP) and programmatic budgets. The region contributes to and benefits from the FCD levy, and it is hoped that the FCD will find the concepts outlined in this Flood Plan in alignment with FCD work program and budget priorities.
- **Tribal governments –** King County is the homeland of indigenous people who have continuously inhabited this landscape since time immemorial. These lands are the ancestral territories of the Coast Salish people, who today are affiliated with the Duwamish, Muckleshoot, Puyallup, Snoqualmie, Suquamish, and Tulalip tribes. Ongoing consultation and coordination between King County and the tribes will be integral to implementing the activities outlined in this Flood Plan to ensure tribal interests and treaty rights are upheld. King County has and will continue to directly invite tribes to be represented on planning committees, comment on environmental reviews and plans, and contribute as partners in planning processes.
- **Federal and state agencies –** Ongoing state and federal coordination is important to the implementation of this Flood Plan, including setting policy and minimum standards, providing funding to leverage local budgets, and collaborating to resolve sometimes competing standards in the implementation of multi-objective efforts. This includes permitting of project activities, compliance with the ESA, adherence to the NFIP Biological Opinion, coordination on dam operations and emergency response activities, and funding for flood protection facility repairs (see *Funding* section later in this chapter for more detail).
- **WRIA salmon recovery groups –** In Washington state, cities, counties, and a range of other interests organized at the scale of major river watersheds (Water Resource Inventory Area, or WRIA) to provide direction to implement watershed-based salmon recovery plans. King County includes two entire WRIAs and portions of two others. Many of the activities identified in watershed-based salmon recovery plans align spatially with areas that experience flood risk. Furthermore, many WRIA priorities for habitat restoration may modify historic flood protection facilities, and projects have the potential to enhance natural floodplain functions in ways that benefit flood risk reduction. Coordination with WRIAs will ensure that mutually beneficial flood risk reduction and habitat restoration opportunities are realized.

Volunteer floodplain restorative planting event with Snoqualmie Tribe in Fall City, February 2020

Ongoing Community Engagement

In addition to continuing to implement current activities and partnering with other governments to advance flood risk reduction, King County recognizes the need to expand its work in local communities, to build relationships and trust, and to move toward co-creation of flood resilience by working with community groups and representatives. By bringing community into the decision-making process and engaging them in defining problems, designing solutions, and implementing programs where feasible, better outcomes will be achieved.

King County developed and implemented an extensive community engagement strategy as part of this planning effort to have a more diverse representation of voices heard when defining needs (Appendix D). Based on lessons learned during community engagement activities to date, the County is interested in expanding its work, particularly in flood-vulnerable communities, to ensure that their needs and interests are understood. This understanding will, in turn, help King County innovate floodplain management programs that better support and meet the needs of community members.

5.2 Advancing Integrated and Multi-Benefit Floodplain Management

As described in the introduction to this Flood Plan and elaborated upon in the goals, objectives, and guiding principles (see Chapter 1), King County has developed this Flood Plan to align with integrated floodplain management principles. A goal of integrated floodplain management is to improve the resilience of floodplains and flood hazard areas to protect communities and the health of ecosystems while honoring tribal sovereign rights (including treaty-reserved fishing, hunting, and gathering rights), supporting values important to the region and local communities, and being efficient with limited financial resources (Ecology 2021).

Swimmers at Tolt-MacDonald Park at Lower Tolt River Floodplain Restoration project site, July 2016

A core component of integrated floodplain management is to improve the resilience of floodplains for community needs and the health of the environment by embracing comprehensive solutions and collaborative decision-making. As an approach, integrated floodplain management takes a holistic perspective and evaluates considerations and opportunities at a reach or watershed scale while seeking to achieve outcomes that provide multiple benefits. In practical terms, this means finding ways to develop solutions that reduce flood risk and restore and support natural floodplain functions while achieving objectives for salmon recovery, the economy, recreation, water quality, viable agriculture, environmental justice, and transportation. Policy 11 in Chapter 1 of this Flood Plan identifies several potential multi-benefit outcomes:

- Climate-resilient public infrastructure, ecosystems, and communities.
- Protected and restored fish and wildlife habitat, including that which supports threatened and endangered salmonids.
- Productive, viable agriculture.
- Safe and sustainable development.
- Opportunities for jobs and economic development.
- Clean water.
- Expanded conservation of open space.
- Enhanced opportunities for recreation and connecting people with nature.

As noted in this plan's policies, flood-prone areas encompass different land uses that are valued by King County and communities within and beyond the county, including developed landscapes that support regional economic activity. Also described in Chapter 1, several state and federal laws and programs intersect with and influence activities in flood-prone areas, including the Clean Water Act, Endangered Species Act, National Flood Insurance Program, and Shoreline Management Act, among others. Effective flood risk reduction reduces flood damage and increases the resilience of communities, and coordinated planning and implementation of activities in flood-prone areas can ensure that trade-offs are adequately considered and that solutions align with integrated floodplain management principles.

Alternatives for flood risk reduction should be informed not just by physical risk, but by the range of other factors described in this plan's goals, objectives, guiding principles, and policies. King County's Comprehensive Plan and Clean Water Healthy Habitat Strategic Plan recommend seeking opportunities to advance multi-benefit outcomes that reflect community priorities and interests as part of broader planning efforts and doing so early in capital project development as part of the initial scoping of alternatives in partnership with the local community.

King County has implemented flood risk reduction capital projects that provide multiple benefits, yet, in many instances, the opportunities to address additional benefits beyond flood risk reduction are identified on a case-by-case basis as part of the design process for individual projects. Adopting an integrated floodplain management approach means moving beyond project-level decision-making to more holistic, reach-based or watershed-scale implementation.

Over the years, King County and partners have developed an array of plans that outline priorities for flood risk reduction, stormwater, open space protection, transportation, salmon recovery, watershed health, agriculture, and other objectives. The various priorities to achieve a range of objectives are largely known. To achieve the systematic multi-benefit outcomes envisioned by this Flood Plan, King County needs to develop a structure for watershed-based portfolio planning that draws on the range of available information about the priorities referenced in this plan, addresses capital and programmatic needs, and drives implementation of these intentional, watershed-based strategies.

The bulleted list above identifies possible outcomes to pursue along with flood risk reduction activities, but it is not exhaustive. The actual benefits provided by different projects should be determined based on local context and community-identified needs. Proactive outreach with local communities during portfolio planning and through the project development phase is required to ensure that the appropriate range of interests are being considered and accounted for as alternatives are developed and activities implemented. Early assessment of opportunities to achieve multiple benefits will result in activities that better meet community needs and responsibly steward public funds and the landscape in which the work takes place.

The following elements are essential for successfully implementing multi-benefit projects. While this framework is focused on project development, this is a foundation from which systematic portfolio planning can occur. Developing these tools and practices will allow King County to formalize collaborative project development and institutionalize approaches focused on multi-benefit outcomes, and these elements can be applied to developing watershed-based prioritization and sequencing strategies as a future body of work. This will ultimately support the type of higher-level, coordinated implementation envisioned by integrated floodplain management.

Including the following steps in the *Water and Land Resources Division Project Management Manual* will support formalizing this approach to multi-benefit project development.

- **Coordination Across County Programs**
  - **Process Improvement –** King County should develop systems and accompanying expectations that foster collaboration across agencies and work programs. Opportunities to work proactively toward multiple objectives should be identified at the earliest phases of portfolio and project planning. A paradigm shift is needed to move away from individual program or funding stream priorities toward actively seeking opportunities to advance multiple public benefits. Such internal coordination can also identify potential external public outreach and engagement needs and opportunities early in project planning and development.
  - **Planning Tools –** King County has multiple plans and policies that intersect with flood risk reduction. The County can improve its systems to identify internal connection points between plans, programs, and policies. Existing county plans and initiatives that connect to flood risk reduction include:
    - King County Comprehensive Plan[1]
    - King County Strategic Climate Action Plan[2]

1 https://kingcounty.gov/en/dept/council/governance-leadership/county-council/topics-of-interest/comprehensive-plan/2024.

2 https://kingcounty.gov/en/legacy/services/environment/climate/actions-strategies/strategic-climate-action-plan.

- King County Clean Water Healthy Habitat Strategic Plan[3]
- King County Regional Hazard Mitigation Plan[4]
- King County Parks Open Space Plan[5]
- King County Parks Leafline Trail Network[6]
- King County Land Conservation Initiative[7]
- King County Local Food Initiative[8]
- King County 30-Year Forest Plan[9]
- WRIA salmon recovery plans (WRIAs 7, 8, 9, and 10)
- King County Stormwater Investment Strategy
- King County Strategic Plan for Road Services[10]
- King County Repetitive Loss Area Analysis (included as Appendix H of this Flood Plan)
- King County Equity and Social Justice Strategic Plan[11]

Project planning and development should consider the needs identified by the above plans and initiatives, which can be facilitated by:

- A geospatial decision support tool that includes data layers from each of these functional areas to support capital planning and project teams in performing an assessment of intersecting priorities.
- Proactive coordination and collaboration where overlapping interests exist to assess the potential for mutually beneficial outcomes or conflicts and to collaboratively establish goals and relative priorities, with reach-scale interests considered at a minimum.

3 https://kingcounty.gov/en/dept/dnrp/about-king-county/about-dnrp/sustainability-commitments/clean-water-healthy-habitat.

4 https://kingcounty.gov/en/legacy/depts/emergency-management/emergency-management-professionals/regional-hazard-mitigation-plan.

5 https://kingcounty.gov/en/dept/dnrp/nature-recreation/parks-recreation/king-county-parks/parks/open-space-plan.

6 https://kingcounty.gov/en/legacy/services/parks-recreation/parks/trails/regional-trails.

7 https://kingcounty.gov/en/legacy/services/environment/water-and-land/land-conservation.

8 https://kingcounty.gov/en/legacy/elected/executive/constantine/initiatives/local-food-initiative.

9 https://kingcounty.gov/en/legacy/services/environment/water-and-land/forestry/forest-policy/30-year-forest-plan.aspx.

10 https://kingcounty.gov/en/dept/local-services/transit-transportation-roads/roads-and-bridges/plans-reports/strategic-plan.

11 https://kingcounty.gov/en/legacy/elected/executive/equity-social-justice/strategic-plan.

- **External Coordination and Consultation**
  - **Tribal Consultation and Coordination –** Government-to-government consultation with tribal partners, as well as outreach at the staff level with tribal natural and cultural resources departments, is needed to ensure projects are developed with an understanding of factors that are most important to tribes and honors their sovereign rights, including treaty-reserved fishing, hunting, and gathering rights.
  - **Engage Partners –** Collaboration with external groups—such as cities, WRIAs, the FCD, Snoqualmie Fish/Farm/Flood, WSDOT, adjacent counties, emergency responders, and others—is needed during planning efforts and, for specific projects, as early in the design process as possible (i.e., at project charter) to develop mutual understanding of interests and identify partnerships upon which integrated floodplain management is based.
  - **Identify Community Needs –** Understanding the needs of local communities is an imperative component of developing equitable flood risk reduction solutions. Engagement with community members and groups about their local interests, concerns, and priorities should inform project goals, including information about flood vulnerability; environmental justice factors; short-, medium-, or long-term adverse impacts of project construction or implementation; and potential adverse and beneficial outcomes on low-income, minority, or other vulnerable communities.
- **Capital Project Planning and Development**
  - **Establish a Shared Vision –** In coordination with county programs and external partners and communities, establish a shared vision that incorporates reach-based considerations and opportunities and reflects multiple interests and benefits.
  - **Develop Alternatives –** Following from the shared vision and the understanding of internal and external interests and priorities, develop project alternatives that reflect the ways these priorities can or cannot be achieved through the design process. External groups, partners, and communities should be included in the alternatives analysis process. Build mutual support for selected alternatives and consider opportunities to develop a portfolio of projects that achieve a shared vision at the reach scale. For example, developing a package of related flood risk reduction, water quality, and habitat restoration projects in a reach could garner broader community and grant funding support and help meet multiple goals.
  - **Evaluate Effectiveness and Communicate –** Track progress in achieving multiple objectives or providing multiple benefits. Communicate successes and challenges with partners and adjust strategies and actions over time based on results.

5.3 Flood Plan Maintenance

Flood Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as progress, roadblocks, or changing circumstances are recognized. King County WLRD is responsible for initiating Flood Plan reviews. To monitor progress and update the mitigation activities identified in the Action Plan, the County will review implementation of this Flood Plan annually. The County will also submit a 5-year written update to FEMA Region X consistent with CRS requirements. With this Flood Plan expected to be fully approved and adopted in 2024, the next Flood Plan update will conclude and be adopted in 2029.

Annual Flood Plan Review Process

WLRD will lead annual evaluations of Flood Plan implementation and create a report per CRS planning Step 10.

The division will convene a committee similar to the Partner Planning Committee to review the progress toward implementation of the Flood Plan's Action Plan. This review will evaluate any changed conditions or progress made on implementation of mitigation activities listed in Chapter 4. During the review process, the following activities will take place:

- King County will engage the public, community organizations, Flood Plan partners, and past participants to inform them of the annual review process and invite their participation on the committee. One-half of the committee must be comprised of members of the public and partners, so that King County can receive full CRS credit for this activity.
- Meetings of the committee shall be published in accordance with local rules regarding public notice.
- The public will also be notified via an advertisement on the County's website specifying the date and time for the review and inviting public participation.
- Prior to the review, county representatives and others identified as implementors of the various activities will be queried about progress on each action.
- Minutes of the meetings and status reports will be prepared by WLRD.
- The results of each meeting will be made available on the County's website and to the County Council for informational purposes, as well as released to local news media.
- WLRD will maintain copies of minutes and status reports to provide to the Insurance Services Office (ISO) and FEMA as part of the community's annual recertification to the CRS program.

King County's annual reviews will include the following:

- Report the implementation status of the mitigation activities in the Action Plan. Completed projects will be noted and project status will otherwise be described.
- Report changes in federal, state, and local policies to determine whether the policy changes will affect Flood Plan implementation or should be incorporated into the plan.
- Report flood or flood-related events that caused damage or closure of businesses, schools, or public services, including:
  - Dates and descriptions of the events.
  - Documentation of damages due to the event.
  - Closures of places of employment or schools and the number of days closed.
  - Road or bridge closures and the length of time closed.

  - Assessment of the number of private and public buildings damaged and whether the damage was minor, substantial, major, or resulted in total destruction. The assessment will include residences, mobile homes, commercial structures, industrial structures, and public buildings, such as schools and public safety buildings.
- Identify improvements to public infrastructure at risk of flooding or the County's flood protection infrastructure.
- Document any new information related to climate change and flood risk that could influence flood risk-reduction decision-making.
- Report new policies or guidance related to equity in flood hazard management.
- Develop and track new equity and social justice evaluation metrics to measure progress toward pro-equity outcomes over time.

5-Year Flood Plan Update

King County's Class 2 rating in the CRS program requires that the County submit an update to this Flood Plan every 5 years to maintain the benefits of that rating. The Flood Plan update will assess any changes in flood-related hazards and reevaluate associated risk. It will also report on the implementation of the last Flood Plan and provide a new strategy for reducing flood risk. This process will include outreach to those who participated in this planning process and others to solicit parties interested in participating in updating and revising the Flood Plan.

A committee of partners and community members, like the Partner Planning Committee, will be convened, and King County will also develop an engagement strategy to involve the diverse voices that reflect county communities, including disseminating information through a variety of media channels detailing the Flood Plan update process. As part of this effort, public comments will be solicited on the Flood Plan update draft. The public outreach process for the Flood Plan update will be coordinated with the program for public information established pursuant to CRS guidelines. King County estimates this planning effort takes a minimum of 3 years. Presuming the King County Council adopts this Flood Plan in 2024, the next planning cycle would begin in 2026, with the commensurate Flood Plan update adopted in 2029.

5.4 Adaptive Management

Adaptive management is a cornerstone of this Flood Plan's implementation strategy. As new technical information associated with King County's flood hazard areas evolves, Flood Plan implementation priorities will be re-evaluated and reported in annual reviews. Shifting Flood Plan implementation priorities over time will reflect King County's more detailed understanding of the level of risk posed by flooding and channel migration to human safety and the regional economy, the degree to which flood risk reduction strategies are working, and the effectiveness of approaches in meeting the needs of King County communities.

Adaptive management requires a commitment to information management. Emerging data, maps, studies, innovative project designs, and monitoring information will be maintained in an accessible and organized format. Informed decision-making will ensure that limited financial resources will be directed to highest risk portions of the floodplain environment.

Adaptive management of major rivers for flood risk reduction requires high-quality, well-organized, and accessible technical information.

5.5 Funding

King County faces challenges to address the variety of flood risks that currently exist and that could emerge due to climate change. Existing funding sources to implement the activities identified in King County's Action Plan include the County's Surface Water Management (SWM) fee, general fund, and other program-specific funding sources authorized in the county budget. However, these sources have statutory limitations that make them unable to meet the funding need on their own.

King County Surface Water Management (SWM) Fee

King County's discharges of surface water must comply with state law and the federal Clean Water Act through its National Pollutant Discharge Elimination System (NPDES) permit. SWM fees are a core source of funding for addressing surface water impacts on water quality and flooding that result from runoff from roads, rooftops, and other impervious surfaces. RCW 36.89.080[12] and 35.67.020[13] authorize the collection of SWM fees by cities and counties. Most cities in King County have their own SWM programs, and they assess fees based on contributions to stormwater runoff and benefits from projects and programs, as authorized by RCW 35.67.020. SWM fee rates, revenues, and programs vary by jurisdiction. In the case of King County's SWM program, a fee is applied to parcel owners in unincorporated areas as set forth in King County Code 9.08,[14] and the revenues help fund a range of services that address flood risk, such as regulations, technical assistance for landowners, drainage improvements, stormwater infrastructure repair and replacement, and restoration projects.

King County's SWM fee is currently assessed based on the amount of impervious surface on a property. For residential parcels or very lightly developed non-residential parcels, a flat fee of $323 per parcel is applied annually. For non-residential parcels that are lightly to very heavily developed, a per acre fee is applied. The per acre fee varies progressively based on the parcel's percent of impervious surface coverage (i.e., correlating to impact), ranging from $898 to $4,916 per acre, annually. For the 2023 – 2024 biennium, projected total revenue from King County unincorporated rate payers is estimated at $88 million, which supports

12 https://apps.leg.wa.gov/rcw/default.aspx?cite=36.89.080.

13 https://app.leg.wa.gov/RCW/default.aspx?cite=35.67.020.

14 https://kingcounty.gov/en/legacy/council/legislation/kc_code/12_title_9.

surface water management projects and programs, many of them mandated by federal and state regulations.

King County Road Fund and General Fund

Other King County funding sources contributing to the activities described in this Flood Plan include the County's Road Fund and the General Fund. The Road Fund contributes to road and bridge maintenance activities described in the King County Action Plan (see Chapter 4), including culvert replacements that improve drainage and conveyance and restore fish passage. The General Fund supports the Office of Emergency Management's hazard preparedness and response activities.

It is important to note that both the Road Fund and General Fund are experiencing long-standing structural funding issues. By voter initiative in 2001, subsequently passed into law by the Washington State Legislature, the amount of property taxes levied by counties is limited to an increase of 1 percent per year, plus revenue from new construction. As a result, revenues counties receive grow at a much lower rate than the cost of maintaining services to residents. This gap is called the "structural gap." While no significant budget deficit is predicted in the 2023–2024 biennium, the budget is not sustainable, and the most recent financial projections indicate up to $100 million deficit in General Fund as the county plans for the 2025 budget cycle.

Flood Control Zone Districts

Counties are authorized by chapter 86.15 RCW[15] to create flood control zone districts for the purpose of undertaking, operating, or maintaining flood control projects, stormwater control projects, or groups of projects that are of special benefit to specified areas of the county. In addition to these purposes, RCW 86.15.035[16] authorizes flood control zone districts to participate in and expend revenue on cooperative watershed management arrangements and actions for purposes of water supply, water quality, and water resource and habitat protection and management.

King County's 2006 Flood Plan reviewed several potential funding sources for flood risk reduction, but – due to the current limitations imposed on those funding sources by state law – none had the potential to generate the level of revenue possible as with a flood control zone district. Consequently, the King County Council established a countywide flood control zone district in April 2007, later named the King County Flood Control District (FCD). The FCD is a separate government from King County. The FCD has made significant and meaningful investments for many flood risk reduction activities in King County, including programmatic activities (such as flood warning and flood hazard mapping) and a wide range of capital activities focused on maintaining and improving the County's flood protection infrastructure, both in incorporated and unincorporated areas.

15 https://app.leg.wa.gov/rcw/default.aspx?cite=86.15.

16 https://app.leg.wa.gov/rcw/default.aspx?cite=86.15.035.

The FCD levies an annual property tax countywide and has since 2008. From 2008 – 2022, the FCD levy raised $723 million for flood risk reduction activities in King County. For 2024, the FCD's adopted budget authorizes collection of $59 million in revenue. Under state law, the FCD may levy up to $0.50 per $1,000 of assessed valuation, although certain technical factors may limit revenue collections above a levy rate of $0.25 per $1,000 of assessed valuation. The levy rate for 2024 is $0.08 per $1,000 of assessed valuation.

Establishment and adoption of the FCD's annual work program and capital budget, as well as establishment of the levy rate, is at the sole discretion of the FCD Board of Supervisors. King County is the primary contracted service provider to the FCD under an Interlocal Agreement and performs many of the programs and projects funded by the FCD.

Grants

The SWM fees and FCD tax revenue are the primary local and countywide funding sources, respectively, for flood risk reduction. Given the scope of projects and project need, and the increasingly multi-benefit nature of projects, it is imperative to leverage local and regional funding with federal and state grants and other funding sources to make meaningful progress on the mitigation activities identified in this Flood Plan. This is especially true of activities identified in the King County Action Plan, which are not funded by the FCD (except for funding provided via FCD grant programs). A wide range of other grant programs are currently in existence that either directly or indirectly support flood risk reduction activities. Examples of these programs—many of which are actively used by King County and partners—are listed in **Table 5-1**.

TABLE 5-1
GRANT PROGRAMS

Funder	Program	Focus
FEMA	Hazard Mitigation Grant Program	Flood disaster recovery, hazard mitigation planning, and community and infrastructure resilience projects
FEMA	Pre-Disaster Mitigation Program	Hazard mitigation planning and community and infrastructure resilience projects
FEMA	Building Resilient Communities and Infrastructure	Capability- and capacity-building, and community and infrastructure resilience projects
Ecology	Floodplains by Design	Integrated floodplain management and multi-benefit floodplain capital project
Ecology	Flood Control Assistance Account Program	Flood hazard management planning and studies
Ecology	Stormwater Financial Assistance	Stormwater management projects
Ecology	Streamflow Restoration Program	Natural resource protection and enhancement, watershed management capital projects, and environmental monitoring

Funder	Program	Focus
Washington Recreation and Conservation Office	Salmon Recovery Funding Board	Natural resource protection and enhancement, integrated floodplain management, and multi-benefit floodplain capital projects
Washington Recreation and Conservation Office	Puget Sound Acquisition and Restoration	Natural resource protection and enhancement, integrated floodplain management, and multi-benefit floodplain capital projects
Washington Recreation and Conservation Office	Estuary and Salmon Restoration Program	Natural resource protection and enhancement, integrated floodplain management, and multi-benefit floodplain capital projects
Washington Recreation and Conservation Office	Washington Wildlife and Recreation Program	Natural resource protection and enhancement, integrated floodplain management, and multi-benefit floodplain capital projects
King County	Conservation Futures	Natural resource protection and enhancement, integrated floodplain management, and stormwater management projects
King County	Parks Levy	Natural resource protection and enhancement
King County	Open Space and River Corridors	Natural resource protection and enhancement, integrated floodplain management, and multi-benefit floodplain capital projects
King County Flood Control District	Flood Reduction Grant Program	Small to medium flood reduction projects, including for stormwater control, urban streams, coastal flooding and erosion, and culvert replacement/ fish passage
King County Flood Control District	WRIA Salmon Recovery Grants	Natural resource protection and enhancement, integrated floodplain management, and multi-benefit floodplain capital projects
King County Flood Control District	Subregional Opportunity Fund	Structural flood control projects, stormwater management, and multi-benefit floodplain capital projects

Federal Partnerships

In addition to grants, federal assistance programs can provide significant funding for repairs to flood and erosion protection facilities. FEMA's Public Assistance Program is available following a federal disaster declaration, and federal funding is no less than 75 percent of the cost of the repair, with the remaining 25 percent being split between the state and local sponsor. Certain disasters, such as the February 2020 floods in King County, have been eligible for a federal cost share of 90 percent, leaving a 5 percent local match requirement for King County.

Another federal program available to repair levees damaged by flooding is provided by the U.S. Army Corps of Engineers through the Public Law 84-99 (PL 84-99) Levee Rehabilitation and Inspection Program. King County partnered with the Corps on several repairs through this program on the Green River between 2008 and 2016, and several repairs are planned for 2024 and 2025. Only levees that meet certain criteria are eligible for funding assistance, and the minimum federal contribution is 80 percent of the cost of the project. Importantly, repairs can only be made to the pre-damaged condition; improvements or enhancements are not authorized.

5.6 Conclusion

King County and partners throughout the county have made significant progress toward building resilience to flood risks, but this Flood Plan reveals that the magnitude of risk that exists along the county's rivers, streams, lakeshores, and marine shorelines remains significant and will likely increase in the years to come due to climate change. The King County Action Plan describes many activities that county agencies will take to reduce flood risk, protect public safety, increase preparedness, and provide a host of other benefits to the county's communities. Further, the Comprehensive Risk Mitigation Strategy outlines an extensive body of work that will greatly enhance flood resilience countywide and for which partner support will be essential. Where the recommendations in this Flood Plan align with the FCD's purpose and goals, it is envisioned that the district will continue to play a key role in sponsoring critical flood risk reduction activities throughout the county. The work of the FCD and the work of other implementers will continue to be critically important.

Much more work is needed to improve the resilience of all communities regardless of location or the type of flood risks they face, and more effort is needed to align King County's flood risk reduction activities with the County's equity and social justice, climate change, and clean water and healthy habitat goals. This Flood Plan proposes policies and actions that attempt to move flood risk reduction in King County toward integrated, holistic solutions that will deliver multiple benefits. However, this Flood Plan ultimately represents a point in time, and it is incumbent upon King County agencies and partners to build on the foundation outlined in the plan, which itself is built on the foundation of work that preceded this plan and informed its development.

CHAPTER 6
References and Source Material

Chapter 1, Introduction

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