PURPOSE OF THE 2013 FLOOD PLAN UPDATE

The *2006 King County Flood Hazard Management Plan* (2006 Flood Plan) is being updated to reflect new information on hazards, vulnerabilities, accomplishments, and proposed actions, and to introduce new policy issues that have emerged since the 2006 Flood Plan was adopted in January 2007. The *2013 King County Flood Hazard Management Plan Update* (2013 Flood Plan Update) is a progress report and companion document to the 2006 Flood Plan; to review current policies and established floodplain knowledge and information, refer to the 2006 Flood Plan.

PLAN UPDATE PROCESS

Citizen Input

King County and the King County Flood Control District initiated a public process to update the 2006 Flood Plan in July 2011 when the Board of Supervisors approved Flood Control District Motions FCD 11-03 and FCD 11-04.1, establishing a scope of work for the five-year update and appointing a citizens committee, which officially convened in December 2011. The scope of work included discussing policy issues that have emerged since the 2006 Flood Plan, reviewing goals and objectives, and updating the action plans for each river basin. The Citizens Committee met seven times between December 2011 and July 2012 to provide input, and staff generated a draft plan update based on this input. Three informal public meetings were held in December 2012 to discuss policy issues and the flood-risk-reduction strategies and action plans for each major river basin. In addition, a number of informal meetings were held with landowners and stakeholders within some basins to solicit input on potential strategies and actions.

In both the Citizens Committee process and the public meetings, considerable attention was focused on capital projects proposed in the action plan. While many of those who commented emphasized the need for "fewer studies and more action," many also emphasized that the region needs a better understanding of how actions relate to the "full picture" of land use changes, development decisions, and other actions that influence flooding in the basin. Many also asked questions along the lines of "How do we know when we will be done" and "What is the end result?" In short, while many thought the flood risk reduction actions were well thought-out and reasonable, they wanted a better understanding of the long-term goal or target for each river system so that they could better understand how specific actions and investments helped to reach that target.

Expert Review Panel Recommendations

During 2012, King County asked an Independent Expert Review Panel to evaluate how well capital project scoping and implementation address four established policy objectives:

- Protecting public safety
- Preventing property damage
- Recovering salmon
- Providing recreation.

The recommendations from this expert panel were discussed with the Citizens Committee. The panel provided several constructive recommendations, including the recommendation that King County incorporate the following elements into strategic river management plans for each major river:

- Summarize the legal drivers and policy mandates that encourage use of ecological/dynamic floodplain management strategies when possible.

- Broadly describe the scientific and applied practice support for implementing ecological/dynamic floodplain strategies (while also identifying when more traditional approaches may be needed).
- Clearly document the river and floodplain management strategy, including project objectives and implementation approaches at the multi-basin, watershed, and river segment scale.
- Summarize programmatic processes by which individual projects are selected, funded, designed, sited, constructed, and monitored.
- Connect policy and programmatic elements to existing flood hazard and salmon recovery plans.
- More clearly identify strategic planning objectives, management actions, and criteria for project selection and implementation.
- Be concise and accessible to staff, agencies, stakeholders and the general public.

For individual capital projects, the panel further recommended that King County do the following:

- Clarify site-specific project goals and objectives and explain how they fit into larger basin-wide or multi-basin strategies.
- Identify potential tradeoffs between objectives for individual projects.
- Communicate key project features and illustrate potential outcomes to help the public and stakeholders understand how those will help meet river and floodplain management objectives.

FUTURE RIVER CORRIDOR PLANNING

As a result of the feedback from citizens, the expert panel, and other government agencies, additional work is necessary to develop river corridor plans that achieve the following:

- Establish desired floodplain management outcomes and levels of service appropriate to each river system.
- Provide a clear description of measurable floodplain management outcomes provided by different levels of investment.
- Document the full life cycle costs and trade-offs between near-term construction and long-term maintenance costs for different capital project alternatives.

Alternative flood risk reduction projects proposed as a result of corridor studies will be analyzed for their costs and benefits, weighing such items as near-term acquisition and construction costs, long-term operation and maintenance, ecological impacts, and other ancillary costs and benefits that would help the public and elected officials make more informed and transparent decisions about significant regional capital investments for public safety and the environment.

This 2013 Flood Plan Update addresses planning elements required to maintain King County's Community Rating System credits as a Class 2 community, while proposing the enhanced river corridor planning approach. A second phase of work will be to create enhanced river corridor plans for each of King County's major river systems.

River corridor plans will inform flood-risk-reduction strategies based on current conditions, determine desired outcomes and levels of service, and offer alternative project approaches to achieve desired

outcomes. Corridor plans are intended to be adopted by amendment as completed, and then combined into one countywide document in a new *2018 King County Flood Hazard Management Plan*.

CHAPTER 1. INTRODUCTION

Chapter 1 of the *2006 King County Flood Hazard Management Plan* (2006 Flood Plan) provides introductory information on the purpose of the plan, goals and objectives, guiding principles and the overall process for plan development. Since adoption of the 2006 Flood Plan, the King County Flood Control District was formed and a citizens committee was convened as a part of the planning process. Updated information to reflect these changes, as well as to document public involvement and the current planning process, is detailed below. Refer to the 2006 Flood Plan for additional background information and status quo material.

GOVERNANCE AND FORMATION OF THE KING COUNTY FLOOD CONTROL DISTRICT

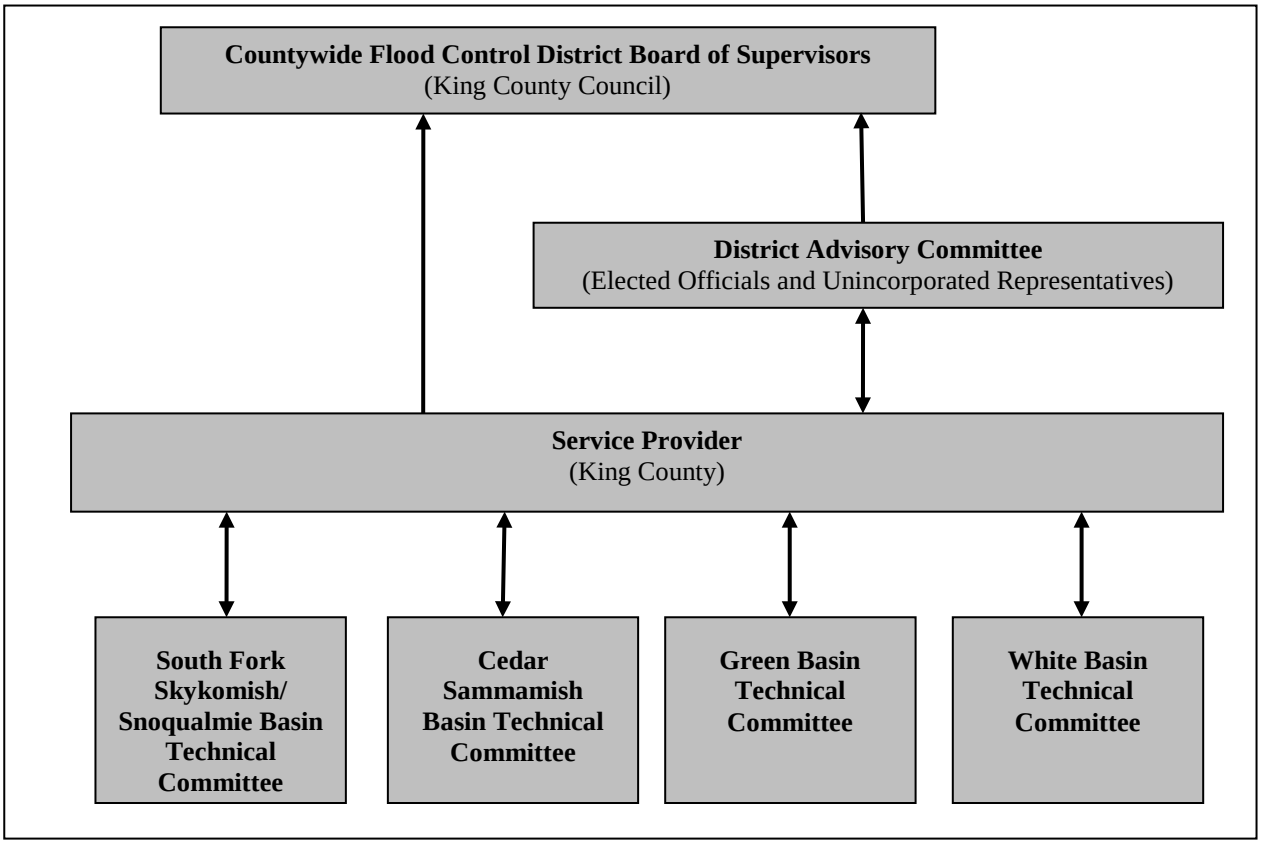
The *2013 King County Flood Hazard Management Plan Update* (2013 Flood Plan Update) builds on regional policies, programs and projects adopted in the 2006 Flood Plan to reduce the risk to people and property from river flooding and channel migration in King County. The 2006 Flood Plan created a long-term vision for flood hazard management of King County's floodplains and recommended specific near-term actions consistent with that vision. In order to fund and guide implementation of those recommendations, the 2006 Flood Plan proposed the formation of a countywide flood control zone district. This district would have property taxing authority and would be led by local elected officials with the decision-making skills necessary to guide such a comprehensive undertaking.

In April 2007, following the recommendation of the 2006 Flood Plan, the Metropolitan King County Council voted to create the King County Flood Control Zone District. The Flood Control Zone District was authorized to use the name "King County Flood Control District" and will be hereafter referred to in this 2013 Flood Plan Update as the District. The Revised Code of Washington authorizes the nine County Council members to be ex officio members of the District's governing body, which is known as the Board of Supervisors (Chapter 86.15 RCW).

The District's governance structure, shown in Figure 1-1, includes an executive committee, advisory committee and basin technical committees. The executive committee, made up of four members of the Board of Supervisors, meets monthly and develops policy recommendations for consideration by the full board. This committee oversees the day-to-day business of the District. The 15-member advisory committee consists of representatives of cities that have historically experienced significant flooding, representatives of the Suburban Cities Association, representatives of areas that are major revenue contributors, and a member from an unincorporated area council. The advisory committee provides the Board of Supervisors with policy recommendations on regional flood protection and annual budgeting issues, and on priorities and implementation strategies for the District's capital improvement program. Basin technical committees, made up of technical staff from local jurisdictions, represent each of King County's major river basins and ensure that basin-scale issues and basin-specific technical information are considered in District decision-making.

In forming the District, the King County Council authorized a property tax levy of $33.2 million in 2008. The property tax is reauthorized annually and is applied throughout the incorporated and unincorporated areas of King County. The estimated 2013 levy collection is $41.3 million. This funding mechanism supports the comprehensive, countywide flood risk reduction program proposed in the 2006 Flood Plan and ensures sufficient funding to address maintenance, repair, and reconstruction of King County's aging flood protection infrastructure.

Figure 1-1
KING COUNTY FLOOD CONTROL DISTRICT GOVERNANCE STRUCTURE
2013 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE



The District is recognized as a stand-alone government by the State of Washington. As a special purpose district, the District's authority for comprehensive floodplain management services is limited. The District does not have land use authority and is not required to comply with the Growth Management Act or the National Flood Insurance Program. King County provides floodplain management services, such as implementing floodplain management regulations to comply with the National Flood Insurance Program and the Growth Management Act, and providing services to maintain the ratings of unincorporated King County and cities under the federal Community Rating System, in which a special purpose district cannot participate.

The District executed and maintains an interlocal agreement with King County whereby the County functions as the service provider to the District for day-to-day implementation of District projects and programs. These services are provided primarily through the Water and Land Resources Division's River and Floodplain Management Section. Because of the cooperative arrangements between King County and the District, this document supports floodplain management services for both unincorporated King County and the King County Flood Control District; the term King County is used to refer to both unless otherwise indicated.

As stated in the 2006 Flood Plan, floodplain management in King County is comprehensive and is implemented at a multiple-agency level. The level of management has evolved in response to state and federal mandates and in response to local flooding conditions. The 2013 Flood Plan Update complements and supports actions implemented under other King County programs relevant to the management of floodplains on smaller tributaries and water bodies. These programs include but are not limited to basin

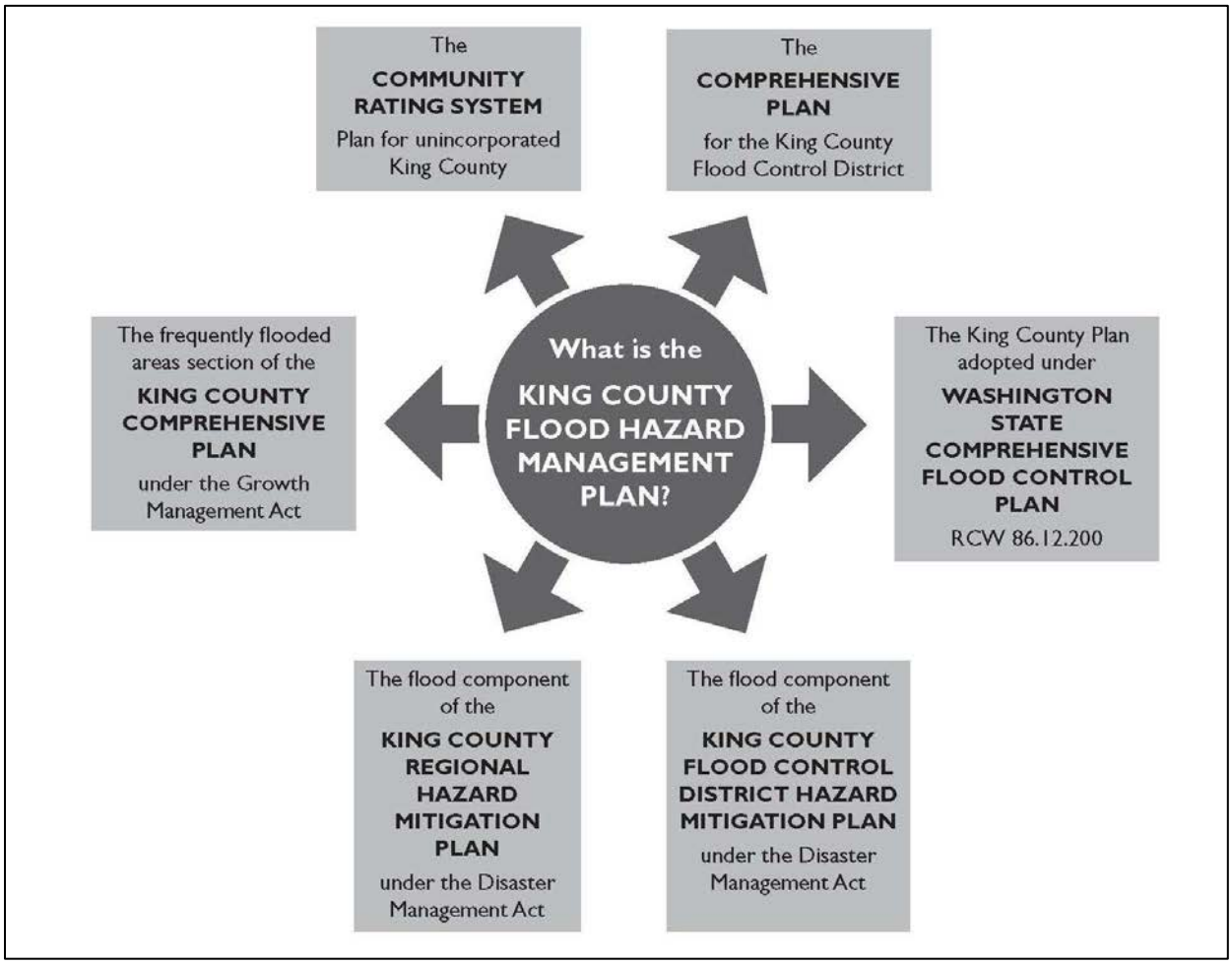
planning, lake management planning, and the management of stormwater runoff using the *King County Surface Water Design Manual*. The elements of the 2006 Flood Plan and the 2013 Flood Plan Update are relevant and applicable to all floodplains and channels within the county.

As shown in Figure 1-2, the 2006 Flood Plan and 2013 Flood Plan Update fulfill requirements of several local, state and federal regulatory programs. They were developed in accordance with the National Flood Insurance Program and the Community Rating System and contribute to the rating of King County and participating cities under the Community Rating System. They also serve as the comprehensive plan of the District, when adopted by the District.

Figure 1-2.

WHAT IS THE KING COUNTY FLOOD HAZARD MANAGEMENT PLAN?

2013 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE



The 2013 Flood Plan Update is a companion document to the 2006 Flood Plan. Both are adopted as a technical appendix to the King County Comprehensive Plan and achieve the following objectives:

- Meet planning requirements for unincorporated King County and participating King County cities under the federal Community Rating System, and maintain a superior rating that allows discounts for flood insurance to community members.
- Serve as the comprehensive plan for the District, when adopted by the District.

- Meet Washington Growth Management Act requirements for addressing frequently flooded areas (King County Comprehensive Plan Chapter 8, Section II. L. and RCW 36.70A.040).
- Fulfill state requirements for developing a comprehensive flood control plan and thus retain local eligibility for state grant funds under the Flood Control Assistance Account Program (RCW 86.12.200).
- Serve as the flood component of the *King County Flood Control District Hazard Mitigation Plan* and the *King County Regional Hazard Mitigation Plan*, thus maintaining consistency with the federal Disaster Mitigation Act and remaining eligible for federal flood mitigation grant programs.

Adoption of the 2013 Flood Plan Update builds on the long-term flood hazard management vision for King County that was established in the *1993 King County Flood Hazard Reduction Plan* and updated in the 2006 Flood Plan. This update reflects changing conditions and new directions in projects and programs since the 2006 Flood Plan was written. Like the earlier flood plans, the 2013 Flood Plan Update seeks to identify specific flood hazard management actions that can be taken to reduce flood and channel migration risks and to protect, restore, or enhance riparian and aquatic ecosystems.

2013 PLANNING AND UPDATE PROCESS

State law governs flood control by county and authorizes flood control districts formed by the County Council to adopt comprehensive plans to guide capital expenditures (Chapter 86.12 RCW).

The 2013 Flood Plan Update is the first update since adoption of the 2006 Flood Plan. The process for updating the 2006 Flood Plan began in July 2011 when the Board of Supervisors approved a motion establishing a scope of work for the five-year update and appointed a 20-member Citizens Committee, which officially convened in December 2011. The Citizens Committee included five members from the 2006 Flood Plan advisory committee. Two of the 20 members appointed to the Citizens Committee declined the offer to serve. The Citizens Committee, convened to serve as a sounding board at key milestones during development of the 2013 Flood Plan Update, reflected urban and rural floodplain interests and included floodplain property owners as well as professionals in the field of engineering and floodplain management. As with the 2006 Flood Plan development process, over half of the members live or work in floodplains.

Intended to inform the development of the 2013 Flood Plan Update, seven Citizens Committee meetings were held before August 2012. All Citizens Committee meetings were open to the public and featured a public comment period. A countywide outreach effort was conducted via direct mailing to all property owners adjacent to the county's major rivers and their tributaries. The mailing informed them of the 2013 Flood Plan Update timeline and next steps. Three public meetings were held in December 2012 to discuss flood-risk-reduction strategies for protecting people, businesses and the County's economic infrastructure. A four-week-long public review and comment period was conducted and a formal public comment period was established on June 14th, 2013, once the draft Plan had been prepared. During the public review and comment period, one countywide public meeting was held (July 9, 2013) to receive comments and recommendations associated with the draft Plan.

CHAPTER 2.
POLICIES

Chapter 2 of the 2006 Flood Plan focuses on policies that provide a framework for making decisions about floodplain management in King County. No changes to Chapter 2 are being proposed for the 2013 Flood Plan Update. However, during development of the 2013 Flood Plan Update, the District identified several policy issues for consideration and discussion by the Citizens Committee. Issue papers and Citizens Committee discussions are located in Appendix L for consideration by the Board of Supervisors. The policy issues considered are described below.

LEVEE CERTIFICATION AND ACCREDITATION

The King County Flood Control District Board of Supervisors has adopted a policy on FEMA accreditation (FCD 11-02) establishing "the intent of the King County Flood Control Zone District to fulfill maintenance and repair responsibilities necessary for certification of individual levee segments when those segments are designed and constructed consistent with flood risk policies in the adopted King County Flood Hazard management Plan." The motion further establishes the District's intent "to address policy issues related to appropriate levels of flood protection countywide, levee certification, including operations and maintenance plans, and Federal Emergency Management Agency ("FEMA") levee accreditation" and asks that this policy review balance the certification and accreditation process and costs with long-term solutions that increase public safety and reduce flood risks throughout the county.

LEVEE VEGETATION AND PARTICIPATION IN PL 84-99

Local governments in the Puget Sound region continue to be caught between conflicting federal mandates: they are required to degrade riparian areas identified as critical habitat for federally listed species so that they can retain eligibility for federal PL 84-99 funding for critical public safety projects. In other words, to comply with one federal mandate local governments must risk violating both the Endangered Species and Clean Water Acts. Since 2009, the State of California Department of Fish and Game and several environmental organizations have filed a notice of intent to sue the U.S. Army Corps of Engineers over vegetation management policies.

COASTAL, SMALL STREAMS AND URBAN FLOODING

Should the King County Flood Control District's capital program include funding for coastal flood and erosion risk reduction projects? How should District funds be allocated for urban flooding and small streams that are not the focus of the 2006 Flood Plan?

SOCIAL JUSTICE AND OUTREACH TO VULNERABLE POPULATIONS

The River and Floodplain Management Section's public service roles are primarily as follows:

- **Assess** flood and erosion risks in King County
- **Communicate** flood risks to the public
- **Reduce** flood risks, including repairing and maintaining levees.

King County passed Ordinance 16948 "establishing definitions and directing implementation steps related to the fair and just principle of the adopted 2010-2014 countywide stragegic plan." The ordinance further specifies "an integrated effort that applies the countywide strategic plan's principle of 'fair and just' intentionally in all the county does in order to achieve equitable opportunities for all people and communities."

How should the 2006 Flood Plan and 2013 Flood Plan Update direct efforts to ensure that the River and Floodplain Management Section is providing these services equitably throughout King County?

PROPERTY ACQUISITIONS AND RELOCATION

When land is acquired for flood risk reduction purposes and tenants are displaced, what types of relocation assistance should be provided? Should any other steps be taken to minimize disruptions to economic activity and mitigate possible impacts on economic development and local tax revenue?

CAPITAL PROJECT PRIORITIZATION AND SEQUENCING APPROACH, CRITERIA AND SCORING

The current capital project prioritization process evaluates the consequence, urgency and severity of flooding and channel migration risks, and sequences project implementation based on factors such as readiness, partnerships, external funding opportunity, and legal responsibility. The fundamental purpose of these criteria is to ensure that limited funding is targeted at the highest priority flood and channel migration risks, and that proposed solutions are consistent with the goals, objectives, and guiding principles in the Plan. With the benefit of the experience in applying these criteria over multiple budget cycles and mid-year revisions, the criteria and scoring system should be assessed with the following questions in mind:

- Do the prioritization scoring criteria adequately define eligible and ineligible projects?
- Do the criteria help decision-makers focus on long-term solutions and getting ahead of the next flood rather than reacting to the last flood?
- Do the prioritization criteria clearly identify when flood damage repairs are necessary to protect public safety and prevent a small problem from becoming larger and more expensive to fix?

BIOENGINEERING

Bioengineering approaches have been applied on King County levee and revetment projects over the past 20 years. Flood risk reduction, ecological objectives, long-term maintenance, recreational safety, and repair costs are taken into account when determining the best approach to levee and revetment repair projects. The issue paper for this topic explains why King County employs bioengineering approaches to levee and revetment projects and why the County needs to update its design guidelines. The following questions have been asked:

- Should King County continue to employ bioengineering techniques and use large wood as a structural element of river projects, given concern about recreational safety?
- Can bioengineering techniques and large wood be incorporated into projects and can public safety be addressed in the design and/or operations of the projects?

GRAVEL REMOVAL AND SEDIMENT REMOVAL

Sediment accumulation in river channels can increase flood hazard and flood risk in King County. The 2006 Flood Plan established a comprehensive sediment management program, which can include gravel removal (dredging) to reduce the flood risk. The issue paper for this topic describes implementation of the sediment management program in specific King County rivers since 2006 and identifies recent actions at the countywide or regional scale regarding sediment management.

CHAPTER 3.
FLOODING IN KING COUNTY

Chapter 3 of the 2006 Flood Plan provides information and context on flooding issues in King County. Specifically, this chapter discusses the types of flood-related hazards experienced in King County, identifying areas at risk, the costs and impacts of flooding and flood related hazards, county participation in the Community Rating System, and general floodplain management practices in King County. New and amended information for the 2013 Flood Plan Update includes the addition of lahar and coastal flood hazards, an updated evaluation of areas exposed to flood-related risks, updated statistics on impacts from flood disasters since adoption of the 2006 Flood Plan, and an updated summary of King County's Community Rating System program. Refer to Chapter 3 of the 2006 Flood Plan for additional information and for elements that remain unaffected.

TYPES OF FLOOD-RELATED HAZARDS

Lahar Hazards

Lahars are rapidly flowing mixtures of rock debris and water, sometimes referred to as mudflows, which originate on the slopes of a volcano and typically flow along a river valley. The White River Valley and the Green/Duwamish Valley downstream of Auburn have been inundated by lahar deposits multiple times in the last 10,000 years, such as the Osceola Mudflow. Although lahars are seldom compared to flooding, their potentially catastrophic consequences make a strong argument for including this hazard in regional disaster planning. Lahar hazards and mitigation strategies share elements in common with those related to flooding; it is appropriate to address these hazards concurrently where they overlap.

Coastal Flood Hazards

Coastal areas 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. Coastal flood hazards with potential to impact the sheltered waters of King County include coastal flooding and coastal erosion. Changes in sea level and climate change further increase the potential impact of these hazards. Coastal flooding results from high water and wave action produced by storm systems. Storm surges, also referred to as storm tides, can affect a number of beachfront areas in King County. Generally, storm surges are caused by an increase in the usual tide level by a combination of low atmospheric pressure and onshore winds. 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.

IDENTIFYING AREAS AT RISK FROM FLOODING AND CHANNEL MIGRATION

King County identifies areas that are at risk from flooding and channel migration using a variety of mapping, analytic, and property-tracking approaches.

Channel Migration Hazard Mapping

Channel migration studies continue, but there have been no substantial changes since adoption of the 2006 Flood Plan.

Flood Inundation Hazard Mapping

Since 2006, King County has made significant progress in mapping the extent of the 100-year floodplain of many of the major rivers; however, not all river floodplain maps have been updated. Table 3-1 shows the total floodplain area along streams and rivers for which a 100-year floodplain has been mapped in both unincorporated and incorporated areas of King County. As river conditions change, the 100-year floodplain may extend beyond currently mapped areas. The mapped 100-year floodplains in King County cover more than 52,000 acres, or close to 82 square miles. As of 2012, there were 6,250 exposed structures in the mapped 100-year floodplains throughout King County, with a total assessed value of over $11.3 billion for combined structure and content value, as listed in Table 3-1. Coastal areas are represented in Table 3-1 under "other floodplain areas."

TABLE 3-1.
LAND AND STRUCTURES LOCATED IN MAPPED 100-YEAR FLOODPLAINS IN KING COUNTY

Total Area in the 100-Year Floodplain (acres)	Structures Within the Floodplain				Potential Damage from 100-Year Flood[a]			
	Number of Structures Exposed	Structure Value Exposed	Content Value Exposed	Total Value (Structure & Content exposed)	Structure Damage[b]	Content Damage[b]	Non-Residential Inventory Damage[c]	Total Damage (Structure, Content & Inventory)[b]
South Fork Skykomish River								
1,969	304	$51,583,037	$36,457,868	$88,040,904	$3,105,745	$5,837,718	$0	$8,943,463
Snoqualmie River								
21,434	2,415	$687,352,588	$509,739,747	$1,197,092,335	$56,370,711	$83,610,859	$32,071,554	$172,053,123
Sammamish River								
4,424	438	$764,857,780	$743,624,587	$1,508,482,366	$24,585,646	$80,554,813	$74,805,591	$179,946,050
Cedar River								
2,204	389	$186,050,029	$144,668,050	$330,718,078	$4,735,725	$2,981,102	$391,139	$8,107,966
Green River								
9,446	1,175	$3,663,127,662	$3,628,333,265	$7,291,460,927	$212,464,070	$673,790,375	$736,289,984	$1,622,544,429
White River								
3,580	196	$36,392,197	$18,470,644	$54,862,841	$3,616,557	$1,760,676	$201,156	$5,578,389
Other Floodplain Areas, Including Coastal Areas								
9,402	1,333	$521,623,330	$334,057,606	$855,680,936	$64,270,441	$58,455,992	$25,540,913	$148,267,347
Total For King County Major Rivers								
52,459	**6,250**	**$5,910,986,623**	**$5,415,351,766**	**$11,326,338,388**	**$369,148,895**	**$906,991,535**	**$869,300,337**	**$2,145,440,768**

a. Estimates do not account for potential losses outside of mapped floodplains, such as in levee-protected portions of the Green River valley.
b. Potential damage estimates from Hazards-United States, or HAZUS, model.
c. Potential inventory losses are estimated using U.S. Army Corps of Engineers depth-damage functions, in conjunction with HAZUS default inventory values determined as a percentage of annual sales per square foot for commercial, industrial and agricultural structures.

Repetitive Loss Areas

FEMA's definition of repetitive loss remains consistent with that in the 2006 Flood Plan. An assessment of King County's repetitive loss inventory since adoption of the 2006 Flood Plan was conducted for the 2013 Flood Plan Update. Currently, the FEMA repetitive loss inventory includes 171 properties in unincorporated King County (Table 3-2). Since 1997, King County has reduced the flood risks associated with 54 of these privately owned properties through the completion of mitigation projects. Twenty-eight

of these were home elevations, and 26 repetitive loss properties were acquired by King County and their structures demolished. All 54 properties have been identified as mitigated within FEMA's repetitive loss property inventory. The 2006 Flood Plan and 2013 Flood Plan Update recommend projects and programs to address the 117 remaining repetitive loss properties, as described in the Action Plan (Appendix F).

TABLE 3-2.
UNINCORPORATED KING COUNTY PROPERTIES ON FEMA'S REPETITIVE LOSS INVENTORY AS OF SEPTEMBER 2012

River Basin	Total Number of Repetitive Loss Properties	Repetitive Loss Properties with Completed Flood Mitigation Actions	Repetitive Loss Properties Not Mitigated
South Fork Skykomish	11	3	8
Snoqualmie River	128	36	92
Sammamish River	3	1	2
Issaquah Creek	3	1	2
Cedar River	19	11	8
Green River	3	1	2
White River	1	1	0
Central Puget Sound (Vashon Island)	3	0	3
Total	**171**	**54**	**117**

Source: King County River and Floodplain Management Program, 2011; FEMA National Flood Insurance Program's Community Rating System Repetitive Loss Properties, 2012.

King County views its total number of repetitive loss properties to be a low estimate of the total number of flood-prone areas, because not all property owners purchase flood insurance through the National Flood Insurance Program. As of April 17, 2012, flood insurance policies for repetitive loss properties made up nearly 4 percent of the total number of flood insurance policies in King County. Between 2006 and 2011, claims paid to owners of flood-insured repetitive loss properties accounted for 49 percent of the total damage claims filed by all flood insurance policy holders. These numbers underscore the need for mitigation measures for repetitive loss properties.

ACTUAL FLOOD DAMAGE AND IMPACTS

Loss of life and property damage remain the two most serious impacts of flooding along the major rivers in King County. To date, major river flooding in King County has infrequently contributed to injury or loss of life; more typically, major river flooding in King County results in property damage. There have been no documented flood-related fatalities in King County since 1991.

Major flood events in King County have resulted in significant property damage. King County has been declared a flood disaster area 13 times since 1990, five of these since adoption of the 2006 Flood Plan. Reported flood-related damage to public property between 2006 and 2012 totals over $50 million, as shown in Tables 3-3 and 3-4. This estimate does not include flood damage to private properties or to publicly owned properties that were not eligible for federal disaster assistance. The information presented in Tables 3-3 and 3-4 represents damage sustained in King County, 33 cities and towns, and 32 other entities, including special purpose districts, state agencies, tribes, and miscellaneous agencies. The events listed include two federally declared disasters that did not technically include flooding.

TABLE 3-3.
FEDERALLY DECLARED FLOOD DISASTERS IN KING COUNTY, 1990-2012: DAMAGE TO PUBLICLY OWNED PROPERTY IN KING COUNTY

Flood Date	Federal Event Number	Estimated Damage: Unincorporated King County	Estimated Damage: King County Cities	Estimated Damage: Special Purpose Districts/Other	**Total Estimated Damage**
January 1990[a]	DR-852				**$5,246,411**
November 1990[a]	DR-883				**$3,694,824**
December 1990[a]	DR-896				**$477,737**
November 1995[a]	DR-1079				**$3,031,519**
February 1996[a]	DR-1100				**$4,226,719**
December 1996[a]	DR-1159				**$3,576,309**
March 1997[a]	DR-1172				**$1,266,446**
November 2006	DR-1671	$3,838,894	$1,225,765	$321,664	**$5,386,323**
December 2006	DR-1682[b]	$2,334,800	$12,570,656	$673,261	**$15,578,717**
December 2007	DR-1734	$661,999	$3,987,495	$474,347	**$5,123,841**
January 2009	DR-1817	$7,767,260	$6,231,751	$2,445,764	**$16,444,775**
December 2008 - January 2009	DR-1825[b]	$1,730,190	$3,678,394	$2,197,966	**$7,606,550**
January 2011	DR-1963		Estimated damage not yet available		
January 2012	DR-4056		Estimated damage not yet available		
Total		**$16,333,233**	**$50,192,931**	**$6,113,002**	**$71,660,171**

a. Only total estimated damage values are available.
b. King County sought federal flood mitigation grant funding under these federally declared disasters, although they did not technically include flooding.

Source: Washington Military Department, Emergency Management Division, 2012

TABLE 3-4.
FEDERALLY DECLARED FLOOD DISASTERS IN KING COUNTY, 1990-2012: LOCAL, STATE, AND FEDERAL COST SHARE TO REPAIR DAMAGED PUBLIC PROPERTY

Flood Date	Event Number	Federal Share	State Share	Local Share	**Total**
January 1990	DR-852	$3,696,349	$615,685	$615,685	**$4,927,719**
November 1990	DR-883	$2,627,506	$437,121	$437,121	**$3,501,748**
December 1990	DR-896	$346,792	$57,798	$57,798	**$462,388**
November 1995	DR-1079	$1,504,057	$250,672.50	$250,672,50	**$2,005,402**
February 1996	DR-1100	$3,476,523	$1,013,332.50	$145,505,50	**$4,635,361**
December 1996	DR-1159	$3,479,123	$579,851.50	$579,851.50	**$4,638,826**
March 1997	DR-1172	$949,834	158,306	$158,306	**$1,266,446**
November 2006	DR-1671	$4,039,743	$673,290	$673,290	**$5,386,323**
December 2006	DR-1682 [a]	$11,684,039	$1,947,339	$1,947,339	**$15,578,717**
December 2007	DR-1734	$3,842,881	$640,480	$640,480	**$5,123,841**
January 2009	DR-1817	$12,333,581	$2,055,597	$2,055,597	**$16,444,775**
December 2008-January 2009	DR-1825 [a]	$5,704,914	$950,818	$950,818	**$7,606,550**
January 2011	DR-1963	Estimated damage not yet available			
January 2012	DR-4056	Estimated damage not yet available			
Total		**$53,685,342**	**$9,380,291**	**$8,116,286**	**$71,578,096**

a. King County sought federal flood mitigation grant funding under these federally declared disasters, although they did not technically include flooding.

Source: Washington Military Department, Emergency Management Division, 2012.

KING COUNTY AND THE COMMUNITY RATING SYSTEM

As of May 1, 2012, 1,211 communities nationwide received flood insurance premium discounts under the Community Rating System. Communities receiving premium discounts through the Community Rating System range from small towns to large metropolitan communities and represent a broad mixture of flood risks, including both coastal and riverine flood risks. In Washington State, 33 communities participate in the Community Rating System program. Although insurance premium discounts are one benefit of participation in this program, more important benefits result from activities that save lives and reduce property damage. Participating communities represent a significant portion of the nation's flood risk, with a significant percentage of the National Flood Insurance Program's policy base located in these communities.

King County began its participation in the Community Rating System in 1990, the federal program's first year of operation. In October 2007, King County became a Class 2 community, which results in up to a 40-percent premium reduction within regulated floodplains and 10-percent premium reduction outside of special flood hazard areas; special flood hazard area is a term used by FEMA to describe the 100-year floodplain. Such areas are required to be regulated by communities participating in the National Flood Insurance Program, and structures in a special flood hazard area are required to purchase flood insurance. As of May 2012, there were 2,725 flood insurance policies in King County; 1,651 of the policies, 61 percent of the total, are for properties located either partially or completely within the floodplain. The remaining 1,074 policies, 39 percent of the total, are for properties located outside the floodplain.

Insurance policy premiums under the National Flood Insurance Program in King County average $665 per policy as a result of the Class 2 rating. As of April 2012, King County's rating amounted to an annual savings of $830,265 to policyholders in unincorporated King County, an average savings of $578 per policy. King County receives credit for 17 of the 18 creditable activities under the Community Rating System. King County's steadily improving Community Rating System classification since 1990 is a function of the County's commitment to comprehensive and cost-efficient floodplain management strategies. King County's ability to maintain or improve its Community Rating System classification will result from successful implementation of the policies, projects, and programs contained in the 2013 Flood Plan Update.

In addition to unincorporated King County, seven cities in the county participate in the Community Rating System: Auburn, Bellevue, Issaquah, Kent, North Bend, Renton and Snoqualmie. These communities obtain some Community Rating System points by activities funded by the District. The City of Kent is the most recent addition to the program, with an entry date of May 2010.

CHAPTER 4.
FLOOD-RISK-REDUCTION STRATEGIES AND TOOLS

Chapter 4 of the 2006 Flood Plan reviews flood-risk-reduction strategies and tools that will aid King County in meeting plan objectives. King County's flood risk reduction efforts are centered on five basic strategies:

- Updating, collecting and managing flood hazard information
- Managing land uses to prevent the creation of new flood risks and to promote flood-tolerant land uses
- Maintaining river channels
- Managing flood facilities
- Providing flood hazard education, promoting flood preparedness and improving flood warning and emergency response.

The 2013 Flood Plan Update provides new and updated information related to flood-risk-reduction strategies and tools in King County. Higher standards such as a 3-foot rather than 1-foot elevation requirement for structures in the floodplain, new flood studies, the National Flood Insurance Program Biological Opinion, and updated education and outreach strategies are a few examples of the elements addressed below. For additional information, or to review elements that remain constant, refer to the 2006 Flood Plan.

FLOOD HAZARD INFORMATION

Primary sources of flood hazard mapping for most communities are Flood Insurance Rate Maps and Flood Insurance Studies published by FEMA. King County and other National Flood Insurance Program communities implement land development regulations using FEMA's 100-year floodplain and floodway and other available flood data. However, FEMA maps are based on current or historical land use. Changing land use conditions and climate trends lead to changing rates and volumes of runoff, so maps can become outdated and not accurately represent the current flood hazard. When watershed conditions change, the 100-year floodplain can expand and flood depths can increase, inundating properties not currently mapped as being within the FEMA floodplain. With additional research allowing predictions of changes in precipitation due to climate change, temperature and snow levels, hydrologic and hydraulic analyses can be used to evaluate how such changes affect river flooding.

King County joined the Cooperating Technical Partner Program in September 2001 and has obtained grant funding to support new mapping on the Lower Snoqualmie River, the shorelines of Vashon-Maury Island, and the incorporated shoreline of King County along Puget Sound. While complete, many of these studies are on hold due to FEMA re-evaluating the approach to mapping levees in floodplains. Under FEMA's program to produce Digital Flood Insurance Rate Maps on a countywide basis, the final release of all maps for a county requires completion of appeal periods for any individual river study. King County Digital Flood Insurance Rate Maps have been delayed pending appeals on the Lower Green River study.

A further delay was incurred due to a proposal by FEMA to evaluate the levee failure analysis procedures presented in its flood hazard mapping guidelines. In December 2011, FEMA released a national public review document describing a proposed policy on procedures for analyzing and mapping areas on the landward side of non-accredited levee systems. The proposed policy presents five options for analyzing and mapping a variety of physical levee settings. The procedures evolved from concerns raised by FEMA stakeholders that the existing methodology did not adequately reflect the level of flood hazard reduction

that levee systems can provide. National Flood Insurance Program communities such as King County and floodplain management organizations such as the Association of State Floodplain Managers and the Northwest Regional Floodplain Management Association submitted comments on the proposed policy and procedures. As of this writing, FEMA has not responded to these comments, provided any further technical guidance, or presented a schedule on when new procedures might be implemented. FEMA has notified King County that any study that includes a non-accredited levee is on hold due to the proposed policy. Major ramifications might occur if FEMA determines that newly updated flood studies that include levee systems must be re-analyzed per any new technical procedures. Re-evaluating levee systems and producing new mapping would be a significant cost to FEMA and to communities such as King County that have spent significant funding on the current updated studies. The National Academy of Sciences released a report in April 2013 stating that FEMA's proposed policy should not be implemented, but should be replaced with a risk-based approach. It is unclear at this time how FEMA will respond to this recommendation from the National Academy of Sciences.

Previous Flood Studies and Mapping

The 1993 *Flood Hazard Reduction Plan* and the 2006 Flood Plan documented conditions based on modeling available at the time for the major river systems in King County. Improving flood hazard data and mapping has been a high priority since then, and King County has completed several major flood studies. To date, nearly all of King County's major rivers and its coastal shoreline have updated flood mapping. Although some of these studies were submitted to FEMA prior to 2006, final federal publication for some has been delayed. Table 4-1 lists completed flood studies that have not yet reached final federal release.

The Lower Snoqualmie River, Patterson Creek and Cedar River flood studies were technically reviewed and approved in 2006 or earlier and are included in preliminary federal mapping of November 2010. The most recent river studies completed by the County are for the following rivers:

- Lower and Middle Green River—For some portions of the Green River, survey data is over 30 years old and cross-sections are spaced over a mile apart. The contour interval of topographic maps is up to 5 feet rather than the more detailed interval of 2 feet in the updated study; a 2-foot interval greatly improves the mapping accuracy of flood hazard boundaries. In some reaches of the river, the channel has laterally migrated since data was collected for the previous flood study. Major commercial, industrial and residential developments, situated behind levee systems in the lower reach, have occurred throughout the basin since the floodplain maps were produced.
- Two reaches of the White River—The previous flood study for the King County portions of the White River used cross-section data collected in 1974. Because the White River is a sediment-rich system with deposition occurring in the lower reaches, the older study is not representative of current hazards.
- Sammamish River—Survey data for the Sammamish River dates from 1965. The contour interval used for previous FEMA flood mapping was 5 feet.

In 2011, King County completed a new flood study and coastal high hazard area maps for Vashon-Maury Island. A study of the incorporated shoreline of the county was initiated and significantly funded by FEMA and conducted as an expansion of King County's Vashon-Maury Island study. The coastline of unincorporated King County was previously last mapped for flood hazards nearly 35 years ago.

TABLE 4-1.
FLOOD STUDIES COMPLETED BY KING COUNTY AWAITING FEDERAL PUBLICATION

River	Study Reach (Length in river miles)	Hydrologic Period of Record	Date of Physical Base Data	Date Submitted to FEMA	Date of Effective FIRM
Cedar River	Elliot Bridge to Landsburg (17 miles)	Two gages: 1946 - 1999; 1920 - 1999	1999 aerials and 1999-2000 topographic maps and channel surveys	December 2002, technically approved in 2003	Preliminary Flood Insurance Rate Map November 2010
Lower Snoqualmie River	Snohomish County line to Snoqualmie Falls (34 miles)	1930 - 2004	2004 aerials, topographic maps and channel survey	May 2006	Preliminary Flood Insurance Rate Map November 2010
Patterson Creek	Mouth to upstream crossing of SR 202 (9 miles)	Three gages: 1991-2005; 1991-2005; 1991-2005	2004 aerials and topographic maps and 2005 channel survey	July 2006	Preliminary Flood Insurance Rate Map November 2010
Lower Green River	16th Avenue Bridge to SR 18	1962-2007	2006 aerials, topographic maps and channel survey	March 2008	Preliminary Flood Insurance Rate Map November 2010
Middle Green River	SR 18 to Flaming Geyser State Park	1962-2007	2006 aerials, topographic maps and channel survey	March 2008	Preliminary Flood Insurance Rate Map November 2010
White River (Zone 2)	King-Pierce county line to Muckleshoot Indian Tribe Reservation	1946-2007	2007 aerials and topographic maps and 2007 and 2008 channel survey	January 2010, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map
White River (Zone 4)	SR 410 near Enumclaw to Mud Mountain Dam	1946-2007	2007 aerials and topographic maps and 2007 channel survey	September 2009, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map
Sammamish River	Mouth at Lake Washington to Lake Sammamish	1948-2008	2009 aerials and topographic mapping and 2009 channel survey	July 2012, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map
Vashon Maury Island	Entire marine shoreline	1948 to 2010 wind data and most recent tidal epoch	2009 aerials and topographic maps	August 2011, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map
Incorporated Marine Shoreline	Marine shoreline Snohomish county line to Pierce county line, and Duwamish Waterway	1948 to 2010 wind data and most recent tidal epoch	2010 aerials and topographic maps	December 2011, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map

Previous hazard mapping for nearly all of the county's marine shoreline was only approximate, with no specific information on flood elevations. The previous maps designated the coastline as Flood Zone A where no detailed wave generation and run-up analysis had been performed. The previous maps did not determine 100-year flood elevations or depths. King County flood hazard regulations for riverine floodplains were not appropriate for coastal floodplains.

The new coastal high hazard area flood maps take into account storm-induced velocity wave action and establish 100-year flood elevations from detailed wave generation and run-up analysis. The new coastal maps provide details for over 110 miles of marine shoreline in the county. New data sets—including aerial photography, topographic mapping, bathymetry data, river channel cross-sections, shoreline transects, hydrologic and hydraulic analyses, and wind and wave analyses—were used to provide the best available technical information following FEMA's technical guidelines (FEMA 2003).

Although final FEMA approval of these studies is still pending, King County regulates new development based on the best available flood hazard data, including the findings of these studies. Best available data also includes data King County has developed that exceeds FEMA standards, such as basin plans that use future-conditions hydrology.

Future Needs

Although a significant number of flood studies have been completed, further effort is needed to continue to update the remaining major river reaches and larger tributary streams in King County:

- Greenwater River—This is a major tributary to the White River. Detailed flood mapping is only available from Pierce County's Digital Flood Insurance Rate Map. But that study is based on regression equations that relate peak discharge-frequency data to drainage area and mean annual precipitation. An updated, detailed flood study is needed to reflect current conditions at a riverside residential community along the lowermost portion of the river.
- White River Above Mud Mountain Dam—This segment of the White River has only an approximate flood study, with no flood elevations and no delineated floodway. Significant flood inundation of State Route 410 has occurred, forcing closure of this state roadway. Fast, erosive floodwaters have exposed riverside residents to life-threatening conditions and loss of homes. New flood hazard information could be used to educate area residents about potential risks and as a basis for planning effective risk-reduction solutions.
- White River Muckleshoot Reach—This segment of the White River has no flood hazard mapping. While much of the river is within Muckleshoot Indian Tribe jurisdiction, developable areas would benefit from accurate delineation of hazard areas to avoid future at-risk land uses.

Although King County has completed numerous river flood studies, studies such as those conducted for the Raging River and Tolt River are based on data that is nearly 20 years old. King County should evaluate whether these studies adequately represent current flood hazards.

Geologic Studies and Maps

Geologic mapping and investigations by the U.S. Geological Survey and the Washington State Department of Natural Resources, conducted in cooperation with King County, directly inform King County flood hazard planning and management efforts.

Channel Migration Hazards and Channel Migration Zone Mapping

Since the 1990s, the science and technology involved in Channel Migration Zone (CMZ) mapping has progressed significantly, and other advances have occurred:

- In King County, preliminary work on CMZ mapping was conducted in 2003 through 2005 for the Cedar River, White River and South Fork Skykomish River.
- In 2004, provisions of the channel migration public rule were incorporated into the King County Critical Areas Ordinance and codified in King County Code Chapter 21A.24.
- At the state level, revisions to the state Shoreline Master Program administrative code required local shoreline updates to map CMZs along all channels within shoreline jurisdiction, and the Department of Ecology issued a publication providing guidance for delineating CMZs.
- The King County Shoreline Master Plan update process in 2011 included a preliminary CMZ mapping designation for channels within shoreline jurisdiction that do not yet have a CMZ map, using the regulatory 100-year floodplain boundary as a surrogate CMZ boundary. Future CMZ mapping will be conducted using standard CMZ mapping methods to delineate CMZ boundaries along these channels.
- King County commissioned a study to evaluate CMZ mapping methods in Washington State, which was completed in 2012.

Based on advances in CMZ mapping, new state CMZ mapping requirements and guidelines, and results of the 2012 CMZ mapping methods study, King County proposes to refine its CMZ mapping methods. This will require revisions to the King County Code and the channel migration public rule. Table 4-2 summarizes the status of CMZ mapping in King County.

Future Needs

There is a need for revision of the King County Code and the channel migration public rule in order to refine King County CMZ mapping methods. King County will coordinate with the Department of Ecology to ensure that refinements to King County CMZ mapping methods remain consistent with the Washington State Shoreline Management Act. Another need is to continue mapping CMZs along other large King County rivers, identified in the 2006 Flood Plan.

The 2006 Flood Plan recommendation for completing CMZ mapping along the Cedar, White and South Fork Skykomish rivers is the highest priority for the remaining large King County rivers. The 2006 Flood Plan also recommends CMZ mapping for the White River upstream of Mud Mountain Dam and the lower segment of the Greenwater River. This 2013 Flood Plan Update further recommends CMZ mapping for the main stem Snoqualmie River downstream of Snoqualmie Falls.

State Shoreline Master Program provisions require that CMZs be delineated and regulated along all channels within shoreline jurisdiction. That jurisdiction extends to all channels with a mean annual flow of 20 cubic feet per second or more, thereby requiring CMZ mapping on several relatively smaller channels, such as Issaquah Creek and Soos Creek. With the passage of time and advances in mapping technology, it would be appropriate to review and update completed CMZ maps based on the extent of channel changes, potential consequences to public safety, and the ability to restrict unsafe development in CMZs. CMZ mapping may be considered for other river segments on other King County rivers, as warranted.

TABLE 4-2.
CHANNEL MIGRATION ZONE MAPPING IN KING COUNTY

River	River Length Description	River Miles	River Length (miles)	CMZ Study & Map Completed?
South Fork Skykomish	County Line to Tye and Foss Rivers	6.4 to 19.9	13.5	In Progress
Lower Snoqualmie	County Line to Snoqualmie Falls	5.9 to 40	34.1	No
Tolt	Mouth to River Mile 6	0 to 6	6	Yes
Raging	Mouth to River Mile 9	0 to 9	9	Yes
Upper Snoqualmie	Snoqualmie Falls to Middle Fork confluence	40 to 44	4	Yes
North Fork Snoqualmie	Mouth to River Mile 1.9	0 to 1.9	1.9	Yes
Middle Fork Snoqualmie	Mouth to River Mile 5	0 to 5	5	Yes
South Fork Snoqualmie	Mouth to River Mile 6.5	0 to 6.5	6.5	Yes
Cedar	City boundary to Landsburg	4 to 22.1	18.1	In Progress
Green	Kent Levees to Flaming Geyser	25.3 to 45.2	19.9	Yes
Lower White	County Line to Mud Mountain Dam	5.5 to 29.6	24.1	In Progress
Greenwater	Mouth to River Mile 1	0 to 1.0	1	No
Upper White	Mud Mountain Dam reservoir to Greenwater	TBD	~ 10	No

Note: CMZ mapping for smaller channels that are within Washington State Shoreline jurisdiction may be beyond the geographic scope of this 2013 Flood Plan Update.

River Corridor

For this plan, the following definitions are used for terms related to areas in and around a river:

- A **river corridor** is defined as the area of a river and surrounding lands that is essential to the storage and conveyance of floodwaters and is integral to natural riverine processes.
- A **river segment** is an area of river and adjacent lands within which the presence, type and extent of flood hazards are similar.
- A **river reach** is defined as a length of river through which similar physical or geomorphic conditions persist.

In general, a river corridor is a larger geographic area that includes one or more river segments, and a river segment is made up of one or more river reaches.

Existing floodplain boundaries, CMZs, landslide hazards, geology, and other information relating to rivers and flood and erosion conditions can be combined to create composite river corridor working maps. These working maps can improve communication among agencies and entities active within flood hazards areas and riparian corridors. Additional information can be overlaid on the working maps to assist in meeting federal Endangered Species Act requirements and coordinating with other King County programs and objectives.

MANAGEMENT OF LAND USES

Flood Hazard Area Regulations

Regulations of land uses in flood hazard areas can be one of the most effective ways of reducing risk from flooding and channel migration. King County has established standards beyond minimum National Flood Insurance Program requirements and developed specific regulatory flood hazard zones. The Critical Areas Ordinance includes higher standards than are required by the National Flood Insurance Program or state law, such as a zero-rise floodway and the use of a 3-foot rather than 1-foot elevation requirement for structures in the floodplain.

Development Within the Zero-Rise Flood Fringe

Key standards for development within the zero-rise flood fringe in unincorporated King County have largely remained the same since the 2006 Flood Plan was adopted. Minor changes include the following:

- Compensatory storage is required at flood elevations equivalent to where storage is displaced. Compensatory storage should normally occur on the site of displacement, but offsite storage may be allowed if approval is granted by King County.
- Development is not allowed if the flood depth is more than 3 feet and the velocity is more than 3 feet per second, except for agricultural accessory structures, roads, bridges, utilities, surface water and flood structures, and public park structures.
- Subdivisions must identify 100-year flood elevations, required flood risk reduction elevations, floodplain and floodway boundaries, CMZs, and building setbacks; ensure adequate drainage away from building sites; and include a notice for any site that is in a floodplain and for which emergency access may not be available during flood events.
- Utilities must be flood-proofed or elevated at least 3 feet above the 100-year flood elevation and are allowed only if no reasonable alternative is available.
- The lowest floor for residential and non-residential buildings must be elevated at least 3 feet above the 100-year flood elevation. Non-residential agricultural buildings with an assessed value of $65,000 or less may be built at grade if flood-resistant materials are used; those over $65,000 of assessed values can request an exception to the 3-foot elevation standard.
- Farm pads and manure storage facilities are allowed through a farm plan if there is no suitable holding area on site that is outside the floodplain.
- Recreational vehicles can be on site no more than 180 days unless they are licensed and ready for highway use.

Development Within the Zero-Rise Floodway

Minor changes to key standards for development within the zero-rise floodway in unincorporated King County include the following:

- Temporary structures and hazardous materials, except for those used in agriculture, must be removed from the floodplain during the flood season, which is from September 30 through May 1.
- New residential structures or improvements to residential structures that are equal to or greater than the market value of the structure are allowed only on lots that were in existence before November 27, 1990 and have at least 5,000 square feet outside the zero-rise floodway.

- Public and private utilities are allowed only if no feasible location is available outside the zero-rise floodway.

Development Within the FEMA Floodway

Minor changes to key standards for development within the FEMA floodway in unincorporated King County include the following:

- New residences and non-residential structures are prohibited in the FEMA floodway except for non-residential agricultural buildings and farm pads within an agricultural production district.
- Maintenance, repair and replacement of existing agricultural buildings, farmhouses, substantially damaged existing residential structures and historic structures in the FEMA floodway are allowed if they meet certain standards.

Development Within Channel Migration Zones

Minor changes to key provisions in the severe channel migration hazard area (one of two portions of the channel migration zone, as defined in the 2006 Flood Plan) include the following:

- Development is limited to structures that do not house humans or animals or store hazardous materials and is allowed only when no feasible location on site is available outside the severe channel migration hazard area.
- Existing primary structures cannot expand their footprint or be improved where the improvement is equal to or greater than the market value of the structure.
- No structure can exceed 1,000 square feet or 10 percent of the severe channel migration hazard area on the site.
- Clearing of up to 1,000 square feet or 35 percent of the severe channel migration hazard area on the site is allowed, and grading of up to 50 cubic yards is allowed on lots less than 5 acres if at least 165 feet from the channel.
- Bank stabilization structures are allowed under limited circumstances.

Development Within Coastal High Hazard Areas

As a participant in the National Flood Insurance Program, King County was required to adopt coastal high hazard area flood regulations to implement the FEMA maps of coastal high hazard areas, also known as velocity flood zones or V-zones. Key standards for development within V-zones in unincorporated King County include the following:

- New buildings and substantial improvement to existing buildings are required to be elevated on pilings and columns.
- The lowest floor must be 3 feet above the 100-year flood elevation.
- The foundation must be anchored to prevent flotation, collapse and lateral movement.
- A registered professional engineer or architect must prepare the structural design.
- The applicant must provide a FEMA elevation certificate prepared by a licensed surveyor documenting the bottom of the lowest floor and whether the structure has a basement.
- King County must maintain copies of the FEMA elevation certificates.
- All new buildings must be landward of mean high tide.

- Non-supporting open wood lattice-work or insect screening that is intended to collapse under wind and wave loads without causing collapse, displacement or other structural damage to the elevated portion of the building or supporting foundation system is allowed.
- The space below the lowest floor must be free of obstruction and used only for parking, access or storage. No human habitation is allowed below the lowest floor.
- Fill is not allowed for structural support.
- Manufactured homes must meet the same standards as new buildings or substantial improvements to existing buildings.
- Recreational vehicles must be on site for fewer than 180 days or be ready for highway use.

National Flood Insurance Program Biological Opinion

On September 22, 2008, the National Marine Fisheries Service issued a biological opinion that implementing the National Flood Insurance Program causes jeopardy to several Endangered Species Act and Magnuson-Stevens Act listed Puget Sound salmonids and southern resident orca whales, as well as adverse modification to their habitat. The National Marine Fisheries Service drafted the biological opinion following consultation with FEMA, in accordance with the judicial order for National Wildlife Federation v. FEMA (U.S. District Court for the Western District of Washington 2004).

Analysis focused on three elements of the National Flood Insurance Program—floodplain mapping, minimum floodplain management criteria, and the Community Rating System. The intent was to assess whether causation exists between activities fundamental to the National Flood Insurance Program and habitat changes that adversely affect listed species and their critical habitat. The biological opinion establishes seven elements of a Reasonable and Prudent Alternative to modify implementation of the National Flood Insurance Program in a manner that would reduce the jeopardy to a level that may affect but would not be likely to adversely affect the listed species:

- **Reasonable and Prudent Alternative Element 1, Notification of Consultation Outcome**—FEMA is required to notify all communities that participate in the National Flood Insurance Program that development under the program could cause jeopardy to several Endangered Species Act and the Magnuson-Stevens Act listed Puget Sound salmonids and southern resident orca whales as well as adverse modification to their habitat.
- **Reasonable and Prudent Alternative Element 2, Mapping**—FEMA should only process Letters of Map Change addressing manmade alterations after determining that the alteration avoids habitat function changes or mitigates for those impacts. FEMA must also ensure that floodplain modeling incorporates on-the-ground data to increase the accuracy of maps depicting the floodplain and to consider future conditions and cumulative effects from future land-use changes, including the risk of flooding behind 100-year levees.
- **Reasonable and Prudent Alternative Element 3, Floodplain Management Criteria**—This element establishes land use and development standards for development within mapped floodplains.
- **Reasonable and Prudent Alternative Element 4, Community Rating System**—FEMA will change the credit given under the Community Rating System to incorporate habitat-based objectives. King County should benefit greatly under these changes because of the County's strong environmental protection policies, regulations, programs and projects.
- **Reasonable and Prudent Alternative Element 5, Addressing the Effects of Levee Vegetation Maintenance and Certain Types of Construction in the Floodplain**—King County and other jurisdictions in the Puget Sound Region, as well as other communities on

the west coast, are working with the U.S. Army Corps of Engineers to modify the Corps' levee vegetation standards for participation in the Public Law 84-99 program or to allow regional variances to those standards.

- **Reasonable and Prudent Alternative Element 6, Floodplain Mitigation Activities**—Any development in floodplains that degrades channel or floodplain habitat and occurs prior to full implementation of Elements 2, 3 and 5 must provide mitigation.
- **Reasonable and Prudent Alternative Element 7, Monitoring and Adaptive Management**—FEMA is required to report to National Marine Fisheries Service on an annual basis regarding progress on implementing the Reasonable and Prudent Alternative elements. National Marine Fisheries Service will determine, in coordination with FEMA, if some alternative actions or additional changes in the Reasonable and Prudent Alternative elements are needed to avoid jeopardy and adverse modification of critical habitat.

The Reasonable and Prudent Alternative element that most significantly impacts local jurisdictions is Element 3: Floodplain Management Criteria, which is summarized as follows:

FEMA shall modify its floodplain management criteria as soon as possible for Puget Sound National Flood Insurance Program communities to do the following:

- Carry out at least one of the following measures:
  - 1) Allow no development in the riparian buffer zone, identified as the greater of the CMZ plus a 50-foot buffer, the riparian buffer width specified by stream type, or the floodway, OR
  - 2) Demonstrate to FEMA that proposed riparian buffer zone development does not adversely affect salmon habitat needs.
- In addition to either 1 or 2 above, carry out at least one of the following measures:
  - 1) Prohibit development in the 100-year flood floodplain, OR
  - 2) Avoid, rectify or compensate for any loss of floodplain storage and fish habitat from development in the 100-year floodplain outside the riparian buffer zone. Any development allowed must use low impact development methods to minimize or avoid stormwater effects. Any indirect adverse effects must be mitigated, OR
  - 3) Mitigate adverse effects on fish or their habitats from structural improvements or repairs resulting in greater than 10-percent increase in structure footprint.

More than 120 communities in the Puget Sound Region must comply with the biological opinion. These communities were divided into three tiers:

- Tier One communities, which include King County, must restore fish populations to a low extinction risk status because their contribution to the abundance, diversity, spatial structure and productivity of the evolutionary significant unit or distinct population segment is critical.
- Tier Two communities may have traits that are important to evolutionary significant unit or distinct population segment viability, but their contribution is less critical.
- All other Puget Sound National Flood Insurance Program communities are in Tier Three.

FEMA has identified three options for National Flood Insurance Program communities to document compliance with the biological opinion:

- Option 1—Adopt the model ordinance developed by FEMA.

- Option 2—Complete a FEMA-developed checklist to document that local regulations and best available science will reduce jeopardy to a level that may affect, but is not likely to adversely affect the listed species.
- Option 3—Perform a case-by-case habitat assessment for development within the mapped 100-year floodplain.

King County selected Option 2 by preparing a programmatic habitat assessment to demonstrate its compliance with the Reasonable and Prudent Alternative elements. This document provides a broad description of salmonid habitat within main stem rivers, streams and lakes, along saltwater shorelines, and in the associated 100-year floodplains. The document identifies the Endangered Species Act- or Magnuson-Stevens Act-listed salmonid species that occupy these areas, and estimates the probable biological effects resulting from development after implementing all of King County's regulatory and non-regulatory programs that are aimed at protecting and restoring these habitats. The assessment was performed at the programmatic level following guidance from FEMA's *Floodplain Habitat Assessment and Mitigation: Draft Regional Guidance* (FEMA 2011).

Using the National Marine Fisheries Service's matrix of pathways and indicators to summarize the environmental parameters affecting Endangered Species Act-listed salmonids, King County assessed current conditions of all the indicators as either "not properly functioning" or "at risk" given the legacy of past land uses. King County does not anticipate additional degradation of any of these pathways and indicators; instead, they are likely on an improving trajectory due to a combined effort of regulations and non-regulatory protection and restoration actions. However, it will likely take years or decades for conditions to change to the point of being considered "restored" as per National Marine Fisheries Services criteria. As a result, King County anticipates that the conditions are conservatively expected to be maintained. Consequently, although the biological opinion establishes a take exemption of 44.16 acres per year for King County, the assessment is that take will not occur, although there may be some minor changes in land use based on development potential in the floodplain.

Development in unincorporated King County is subject to a range of recently updated shoreline, critical area, clearing and grading, and stormwater regulations, all of which were developed through substantial use of best available science as required under the Washington State Shorelines and Growth Management Acts. Furthermore, as noted in the biological opinion, the County's floodplain regulations exceed the minimum requirements of the National Flood Insurance Program. Taken together with non-floodplain regulations and a wide range of King County programmatic actions—such as the transfer of development rights program, open space acquisitions, ecological restoration projects, and low density zoning—the floodplain regulations "minimize the effects of floodplain development on fish habitat and habitat forming processes" (National Marine Fisheries Service 2008). The programmatic habitat assessment and evaluation of potential future development impacts confirms the National Marine Fisheries Service's conclusion and further demonstrates that future development impacts may affect but are not likely to adversely affect protected species in King County's watersheds.

Technical Assistance and Consultation

King County can help public and private entities make wise land use decisions to reduce flood-related risks by sharing expertise in hazard identification techniques and by reviewing and coordinating planning and design efforts by public and private entities that overlap, impact or are impacted by flood hazard areas. In addition to the information covered in the 2006 Flood Plan, the following reflects new and updated information.

Salmon Recovery and Riparian Habitat Conservation

King County's floodplains and river corridors directly support three distinct salmonid stocks and indirectly support one distinct stock of marine mammals that are listed as threatened under the Endangered Species Act:

- The Puget Sound Evolutionarily Significant Unit of Chinook salmon (*Oncorhynchus tshawytscha*) (Myers et al. 1998; Rosenberg 1999)
- The Puget Sound Evolutionarily Significant Unit of steelhead trout (*Oncorhynchus mykiss*) (Hard et al. 2007; Oliver 2008a)
- The West Coast/Puget Sound Distinct Population Segment of bull trout (*Salvelinus confluentus*) (Barry 1999).
- The Southern Resident population of killer whales (*Orcinus orca*), listed in 2005 by the National Oceanic and Atmospheric Administration as endangered under the Endangered Species Act (Hogarth 2005; Carretta et al. 2010; National Marine Fisheries Services 2011). These orcas spend several months of the summer and fall each year in Puget Sound, including in nearshore areas of Vashon Island in King County.

Puget Sound coho salmon (*Oncorhynchus kisutch*) and Puget Sound pink salmon (*Oncorhynchus gorbuscha*) are listed under the Magnuson-Stevens Act. This act requires identification of essential fish habitat (Oliver 2008b), defined as the waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity. The act requires federal agencies to consult with the National Oceanic and Atmospheric Administration on activities that may adversely affect essential fish habitat.

Washington State Department of Ecology has divided the state into 62 Water Resource Inventory Areas, or WRIAs, to delineate the state's major watersheds. Within King County there are four WRIAs:

- WRIA 7, Snoqualmie (extends into Snohomish County)
- WRIA 8, Cedar/Sammamish (extends into Snohomish County)
- WRIA 9, Duwamish/Green and Vashon Island
- WRIA 10, Puyallup/White (extends into Pierce County).

With the listings of salmonid species as threatened under the Endangered Species Act, a number of partnerships were formed to develop conservation plans for individual WRIAs, with the specific goal of recovery of listed species and their essential fish habitat. In 2007, the Puget Sound Partnership was formed. This state agency works with citizens, governments, tribes, scientists and businesses to restore and protect Puget Sound. Through the work of the Partnership and local implementing groups, actions identified in the conservation plans are being implemented to restore salmonid populations and their essential habitat.

Most floodplain management projects are multi-objective, including improvement of listed species habitat degraded by past land use and floodplain management activities. When habitat elements are incorporated into the design of levees and revetments, funding from multiple sources often can be leveraged and habitat conditions can be improved. King County also looks for opportunities to set levees and revetments back from the river edge, or to remove them entirely to provide for more floodplain storage and conveyance, which also benefits salmon. Reconnecting floodplains that have been disconnected by past land use and floodplain management actions also increases the resilience of the river system to impacts from climate change.

RIVER CHANNEL MAINTENANCE

King County policies provide guidance regarding the application of channel maintenance actions. The following sections provide background information and recommendations for future actions.

Sediment Management

Sediment management, as referred to in this document, is a program to reduce the flood risks that result from sediment accumulation in channels. In this program, flood risks can be reduced either by removing sediment from the channel in order to increase channel flood conveyance—commonly referred to as gravel removal—or by removing existing structures from the area that is subject to flood hazards induced by sedimentation. Either of these approaches is a sediment management action in this program. Gravel removal is a type of sediment management action, but it is not synonymous with sediment management. Strategies that King County may use to manage the accumulation of sediment as it affects flooding in King County's rivers are described below.

Channel Monitoring

Channel monitoring provides information on sediment accumulation and its effect on channel capacity by characterizing existing conditions, quantitatively documenting changes in in-channel sediment levels through time, and evaluating corresponding changes in floodwater levels. While King County uses channel monitoring results to inform potential sediment management decisions, this same information would be required as part of the permit process for any gravel removal operation.

In-channel sediment levels can be monitored by collecting topographic data using a variety of methods, including traditional survey, bathymetric sonar readings combined with survey-grade GPS, aerial orthophotography, light detection and ranging (LiDAR), or combinations of these. Whatever the means of data collection, each data point is referenced to an established coordinate system so that the data collected at any given time can be compared accurately to similarly referenced data collected previously or subsequently. Channel monitoring data typically are configured as channel cross-sections—lines generally running perpendicular to the direction of flow—or they can be used to generate a digital topographic surface if the collected data are of sufficient density. Repeated collection of monitoring data over time intervals of one to several years in the same river segment allows quantitative comparison of riverbed and gravel bar surface elevations and calculation of changes in sediment deposition or erosion during the intervening time period.

Channel monitoring allows evaluation by hydraulic modeling of the effect of changes in sediment levels on floodwater levels. Typical hydraulic modeling is accomplished by using new survey data to update an existing 1-dimensional hydraulic model that was created for a flood study in the area. Hydraulic modeling results identify whether there have been significant changes in modeled floodwater levels or channel capacity that are attributable to changes in sediment levels.

The channel monitoring component of the King County sediment management program is conducted in the following river segments:

- Lower Tolt River near the City of Carnation
- Lower Raging River
- South Fork Snoqualmie River along the City of North Bend
- Middle Fork Snoqualmie River near North Bend
- The main stem Snoqualmie River near Fall City and Carnation

- Lower Cedar River
- Lower White River along the Cities of Auburn and Pacific.

The City of Renton conducts channel monitoring for the lower 2 miles of the Cedar River. King County collaborates with the City of Auburn in collecting channel data in a 1.25-mile stretch of the Lower White River.

In-channel sediment levels have been monitored and associated hydraulic modeling has been conducted in these river segments at various intervals since the mid-1990s. King County also has assembled survey data collected by others from previous periods, some of which date back to the 1960s.

Sediment Management Actions, Including Gravel Removal

The 1999 listing of Puget Sound Chinook salmon and bull trout as threatened under the Endangered Species Act and the 2011 revisions to the *Washington State Shoreline Master Plan Guidelines* may further limit gravel removal operations. Any gravel removal proposal would need to consider and be coordinated with existing or proposed gravel augmentation projects that may be in effect for habitat restoration or similar purposes.

Sediment Management Program

The sediment management program is being applied in all monitored river segments listed earlier in this section. The extent to which the program components have been implemented varies by river segment, as does the sediment management action that is likely to be taken:

- In the Lower Cedar River, annual channel monitoring by the City of Renton indicates that ongoing sediment accumulation is decreasing channel flood capacity below the identified flood protection objective. A maintenance dredging project is slated to be conducted as part of continued implementation of the 1998 Cedar River 205 Flood Control Project, and carried out as part of the King County Flood District 6-year CIP list, with the City of Renton as local sponsor. A 205 project is a project carried out by the U.S. Army Corps of Engineers under Section 205 of the 1948 federal Flood Control Act. Section 6.3.6 describes eligibility for such projects
- On the South Fork Snoqualmie, channel monitoring data indicated loss of channel capacity due to sedimentation, so an analysis of gravel removal scenarios was conducted (King County 2011). That study indicated some potential for localized flood hazard reduction effectiveness from gravel removal, and the study results are being incorporated into the overall South Fork Snoqualmie levee improvement project planning and design process, in which a full range of flood risk reduction alternatives is being considered.
- On the Lower White River, ongoing, widespread and rapid sediment accumulation has significantly decreased the channel capacity (Herrera 2010), with locally increased flooding and damage in January 2009 (Czuba et al. 2010). Setback of existing levees has been identified as the preferred approach for flood risk reduction in this river reach. Although gravel removal was evaluated generally in this river reach and found to be much less effective in reducing flood levels than levee setback (Czuba et al. 2010), a more specific evaluation of gravel removal will be prepared as part of the advanced design and review process for the levee setback project.
- On the lower segments of the Raging and Tolt rivers, the main stem Snoqualmie River along Fall City and Carnation, and the Middle Fork Snoqualmie River, channel monitoring under the sediment management program is ongoing. Consideration of sediment management action

alternatives is yet to be completed for these river segments, although channel monitoring data have been used in basin-scale flood reduction strategies now underway, such as the Tolt River Corridor Plan, the Middle Fork Snoqualmie Corridor Plan, and the Snoqualmie River at Fall City levee setback project design. Gravel removal will be analyzed for flood reduction effectiveness in these river reaches if the channel monitoring results demonstrate ongoing increases in flood hazards attributable to in-channel sedimentation.

Management of Naturally Occurring Wood in King County Rivers

The 2006 Flood Plan provides a description of the important role of naturally occurring wood in rivers and an historical context of its management which is not repeated here. Since the 2006 writing there has been a change in terminology, where the scientific and floodplain management communities no longer use the term "large woody debris" to reference natural wood. Moreover, there have been developments in our understanding that although some naturally deposited wood may not directly pose flood-related risks, it may increase public safety hazards to river and floodplain users. Once evaluated, these identified risks may warrant management actions.

King County's contemporary design approaches for river and floodplain projects allow the river to more closely mimic natural floodplain processes for flood storage and conveyance. Site changes resulting from these new approaches can lead to the recruitment or accumulation of naturally fallen wood in the vicinity of project sites. Large-wood recruitment may even be an intended project feature, contributing to the achievement of project objectives.

While King County's approach to managing natural large-wood accumulations has changed dramatically, common understanding about the beneficial functions of wood in rivers is still evolving, and the County continues to routinely receive requests to remove fallen trees from river channels. Existing policy directs King County to dislodge, cut or remove naturally occurring large wood only where the material poses an imminent flood-related threat to public safety or infrastructure. Where action is deemed necessary, solutions that reduce the imminent flood risk with the least disturbance to the wood and the surrounding river environment are preferred. For example, minor repositioning or trimming of large wood so that it can remain in the channel or adjacent floodplain is preferred to wholesale removal of the wood from the riparian area. This approach is intended to address situations of flood-related public safety threat while avoiding adverse impacts on the habitat of fish and wildlife.

Under current practice, all reports of public safety concerns, including those related to recreational use involving large wood, are directed to the King County Sheriff's Office. The King County Sheriff's Office investigates each report within its jurisdiction and makes a preliminary assessment of potential risk. If there is an imminent threat to public safety, the King County Sheriff's Office initiates emergency actions. Otherwise, the King County Sheriff's Office coordinates with River and Floodplain Management Section staff to evaluate the hazard, determine if there is elevated risk to flood protection infrastructure or public safety, and identify possible action responses. The King County Sheriff's Office selects a preferred action response. The River and Floodplain Management Section provides expertise in the geomorphology, ecology and engineering features of the site, assists in obtaining permits, and provides oversight for the use of heavy equipment, if used in the operation. When risks are unavoidable, the King County Sheriff's Office may use its legal authority to close a portion of the river to recreational use and passage until the risk is resolved. In incorporated areas outside the jurisdiction of the King County Sheriff's Office, River and Floodplain Management Section staff will evaluate the hazard for any flood-related risks, determine appropriate action and coordinate with local authorities.

Special consideration is given to the management of natural wood when it is associated with a King County flood hazard management project. Beginning in 2012, King County has committed to an

enhanced degree of communication regarding river projects, intended goals, possible outcomes and the range of adaptive management tools expected to be used on the site. When a project is expected to affect recruitment, mobility or accumulation of natural wood, King County proactively engages in a dialogue with nearby residents and interested citizens and considers public safety in all phases of the project, from design through monitoring, maintenance and adaptive management. Project-specific or area-specific plans for long-term and adaptive site management will describe anticipated wood movement and accumulation patterns, evaluate the nature and degree of public safety risk associated with the wood, and make recommendations consistent with adopted policies and project objectives.

To inform such analysis, information on locations of natural large-wood accumulations is beneficial. In 2009 King County conducted a pilot study to describe the location, character, functional value and potential flood-related and river recreational risks associated with large-wood accumulations in the lower reaches of the Cedar River. In 2010 an additional pilot study was conducted to characterize recreation use on this portion of the Cedar River. This pilot study information has proven to be a valuable resource for project managers planning capital improvement projects on the Cedar River.

Naturally Occurring Landslide Management

Landslides are common features in river and stream valleys across King County. While small landslides are often a result of human activity, the largest landslides are often naturally occurring phenomena with little or no human contribution. The sites of large landslides are typically areas of previous landslide movement that are periodically reactivated by significant precipitation or seismic events. Such naturally occurring landslides can disrupt roadways and other infrastructure lifelines, destroy private property, and cause flooding, bank erosion and rapid channel migration. Landslides can create immediate, critical threats to public safety. Engineering solutions to protect structures on or adjacent to large active landslides are often extremely or prohibitively expensive. In spite of their destructive potential, landslides are a part of the natural landscape of King County river valleys. They supply sediment and large wood to the channel network and can contribute to complexity and dynamic channel behavior critical for aquatic and riparian ecological diversity. Effective landslide management should include the following elements:

- Continuing investigation to identify natural landslides, understand their mechanics, assess their risk to public health and welfare, and understand their role in ecological systems
- Regulation of development in or near existing landslides or areas of natural instability through the King County Critical Areas Ordinance in King County Code Chapter 21A.24, the clearing and grading standards in King County Code Chapter 16.82, and the *King County Surface Water Design Manual*
- Preparation for emergency response to landslides to facilitate rapid, coordinated action among King County and local cities, state and federal agencies, and to provide emergency assistance to affected or at-risk citizens
- Evaluation of options including landslide stabilization or structure relocation where landslides are identified that threaten critical public structures or infrastructure, such as the Auburn-Black Diamond Road project and the Sinnema Quaale Upper Project.

FLOOD PROTECTION FACILITIES

King County monitors, inspects and maintains an extensive inventory of flood protection infrastructure, much of it initially constructed in the middle of the last century. Prior to 1993, flood hazard management efforts in King County relied heavily on constructed flood protection infrastructure to inhibit flooding, erosion and channel migration. Since 1993, portions of this infrastructure have been repaired or retrofit using newer techniques such as bioengineering. The County's flood protection infrastructure includes

rock-faced levees and revetments, biostabilized revetments, overbank channels, instream structures, pump stations and associated appurtenances. The terms “flood protection infrastructure” and “flood protection facilities” are used interchangeably in this document.

Levees

Levees are raised embankments built adjacent to rivers and are designed to contain or direct flood flows when river water surface elevations would naturally inundate the surrounding floodplain. Total footprint dimensions of a levee depend on the length, height and side slopes of the levee; some levees extend for miles along river corridors such as the Green River and South Fork Snoqualmie River. Existing levees in King County provide a highly variable level of service or level of protection. Flood flows contained by levees may have a recurrence interval ranging from 10 years to 100 years.

Vegetation Guidelines

U.S. Army Corps of Engineers guidelines suggest that vegetation be cut to prevent root systems from penetrating the levee prism, which is thought to create instability and geotechnical concerns. However, recent research has called this generalization into question and suggests a more complex situation in which stability is the result of several interrelated characteristics, including type of vegetation, soils and construction, and location on the levee. In addition, rock armor on the face of the levees interferes with the development of riparian conditions needed for fish and wildlife. King County is developing uniform and contemporary standards for inspection, assessment, monitoring and maintenance to improve the condition of this flood protection infrastructure. The U.S. Army Corps of Engineers promotes the use of federal standards that dictate minimum levee dimensions with respect to containment and freeboard and removal from levee slopes of all vegetation greater than 2 inches in diameter. The Seattle District of the U.S. Army Corps of Engineers has operated under a regional variance developed in response to the federal Water Resources Development Act Amendments of 1997, which allows vegetation up to 4 inches in diameter and the use of engineering discretion in determining when vegetation poses a risk to levee stability, emergency access or inspections.

In 2009, the U.S. Army Corps of Engineers proposed a policy change that would repeal existing regional variances and create a process for variances to be obtained for individual levee systems. A separate process has also been created to develop System-Wide Improvement Frameworks in which flooding problems are collaboratively prioritized by multiple stakeholders so that any risks posed by vegetation can be compared alongside other risks to levee stability and resilience. Since 2010, King County has been working with a team of state and federal partners, including the Seattle District of the Corps and the Puget Sound Partnership, to develop an alternative vegetation management framework that would achieve the following goals for levee vegetation management in Western Washington:

- Safe and Effective Levees—Resilient structures that can be accessed and inspected during floods
- Functional Habitat—Recognition that, in many densely developed locations, levees are the riverbanks
- Cost-Effective—Use of limited resources to address the worst problems first
- Science-Based—Responsiveness to new information and research.

It has not yet been determined whether these goals will be achieved through a vegetation variance, a System-Wide Improvement Framework, or a combination of the two, nor have any proposals been evaluated to determine if they are compliant with the federal Endangered Species Act or Clean Water Act.

Accreditation and Certification

Eligibility requirements for the Public Law 84-99 flood damage repair program are often incorrectly perceived as synonymous with federal guidance for levee accreditation by FEMA. In fact, the two programs are completely separate. Certification and accreditation are parts of a process administered by FEMA under the National Flood Insurance Program for floodplain insurance mapping purposes. Land behind FEMA-accredited levees is not shown as floodplain on federal Flood Insurance Rate Maps, and is therefore not subject to federal insurance requirements or floodplain development regulations. FEMA levee accreditation requires prior certification by a professional engineer that the levee meets design standards to provide risk reduction for the 100-year flood. According to the National Committee on Levee Safety (2009), this certification is often misperceived as a safety standard. As the American Society of Civil Engineers concluded, "levee accreditation under the FEMA regulation is a technical finding for the National Flood Insurance Program that is not in any way a representation that any accredited levee will provide for the safety, health, and welfare of the public."

Currently, only one public and one private levee in King County are mapped as accredited levees on Flood Insurance Rate Maps. Levees that meet FEMA certification standards may in some cases provide a greater level of safety and property protection than levees that provide less than 100-year protection. Flood insurance in areas protected by certified and accredited levees is less costly or not required. However, certified levees do not provide a guarantee against flooding, as any levee can be compromised or overtopped in a large enough event. FEMA accreditation may unintentionally increase the residual risk from a large flood event by enabling development in the levee-protected area and giving residents the perception that they are protected from a flood and do not need to obtain flood insurance or otherwise manage their own risk. Upgrading existing levees in King County to meet federal accreditation requirements, some of which would require complete replacement, would cost hundreds of millions of dollars. Given this high cost, as well as the residual risk concern, a cost benefit assessment and consideration of policy tradeoffs would be necessary to determine the feasibility and appropriateness of constructing certified levees.

The 2013 Flood Plan Update calls for the development of a level of service target for individual river reaches based on flood and channel migration risks and the potential of levees and revetments to reduce those risks in a cost-effective and environmentally sustainable manner. FEMA accreditation for insurance mapping purposes may be determined to be appropriate in some contexts, but it should not be considered a design goal for public safety purposes.

Revetments

Revetments are not eligible for the Rehabilitation and Inspection Program available to qualified levees, and therefore lack a similar standard for design and maintenance. As such, revetments are not subject to U.S. Army Corps of Engineers standards for vegetation management. Increasingly, the County is using biostabilization techniques or incorporating native vegetation into designs as means to increase soil stabilization and provide improved conditions for fish and wildlife. While FEMA does not specify vegetation management requirements, the agency often views the presence of vegetation as evidence of deferred maintenance, despite FEMA reports that encourage the use of vegetation to stabilize revetments.

Management Considerations

Structural approaches such as levees and revetments must be incorporated into a broader risk-reduction strategy that includes risk avoidance, risk awareness, and other mitigation actions to ensure that the public is aware of remaining flood risks and is able to take appropriate action to manage this risk. As part of the broader basin strategy, level of service targets should be developed for individual river reaches and should consider physical factors such as channel capacity, land use factors such as population density and

development patterns, and environmental factors such as salmon habitat and water quality goals. Basin strategies and level of service targets will be reviewed under King County's Equity and Social Justice program to ensure that King County citizens are provided equal access to flood risk reduction services.

Risks Associated with Encouraging Floodplain Development

Risk always exists that a levee may be overwhelmed during an extreme flood event, even if it is accredited by FEMA for floodplain mapping purposes. Floodplain communities across the United States have learned that by encouraging development and reducing risk awareness, FEMA accreditation of levees can help to turn a manageable disaster into a catastrophe.

Very few of the levees in King County were designed to withstand the 100-year flood, and levees along the Lower Green and the South Fork Snoqualmie that were previously recognized by FEMA as accredited were never in fact certified. Even when a levee is certified and accredited, the possibility of failure exists in the unlikely but possible event of a large flood that exceeds the levee's design capacity. This can have a devastating impact on financial resources.

Effects on Recreational Users

Levee and revetment repair and reconstruction projects by their nature modify the river environment:

- Repair projects typically retain the existing alignment of a levee or revetment, but may modify the materials used in its construction and in some cases the local geometry of the river bank by incorporating flow deflectors, root wads or engineered log jams.
- Reconstruction projects more significantly alter the river. In some cases they may relocate a levee and encourage natural river processes to rework a portion of the floodplain so that the river becomes more dynamic and less predictable but is able to store floodwaters and sediment and create and maintain diverse habitats.

Because repairs and reconstruction result in new conditions along the river, they may change the experience of recreational users boating, floating, swimming, wading or walking along the river's banks. These changes may result in new or evolving hazards in the vicinity of a project, including placed and secured or naturally recruited large wood, rock structures that can impede flows, and overhanging vegetation. Potential risks associated with project elements such as these are considered during project design, in the context of the river environment's naturally occurring hazards such as cold, swift water, naturally occurring large wood, and undercut banks with steep drop-offs.

Level of Service Considerations

The term "Level of Service" refers to a specified goal for flood protection that a levee or levee system is intended to provide. Existing flood protection infrastructure in King County provides a highly variable level of service or level of protection. Flood flows contained by King County levees may have a recurrence interval ranging from 10 years to 100 years. Flood protection infrastructure is only one of many tools and factors to consider when developing flood-risk-reduction strategies for each river basin, and must not be considered in isolation.

Currently, there is no level of service standard for flood protection infrastructure established for any of King County's river basins. King County's Comprehensive Plan has the following policy associated with risk-reduction level of service:

> **F-290** King County should assess the most appropriate level of service for flood risk reduction along river segments based on existing and predicted development density, land use, and hydrologic conditions.

The river systems in King County are highly variable from river to river and from reach to reach within a given river. These contributing factors of variability must be considered in level of service discussions:

- Existing land-use and development patterns and density in the adjacent floodplain—The type and density of land uses and the assessed value of land and improvements varies significantly throughout King County.
- Presence of existing flood protection infrastructure—The two most common types of flood protection infrastructure in King County are levees and revetments. Presence of levees and revetments vary by river and river reach.
- Channel capacity, including channel gradient and width, sediment transport, aggradations, or erosion—Transport and deposition of sediment (sand, gravel, cobble, and boulder) and woody material are affected by sources, loading, flood protection infrastructure, and channel conditions such as gradient and width.
- Critical salmon habitat areas and salmon spawning and rearing habitat—All rivers in the geographic scope of this 2013 Flood Plan Update are used by salmon, with the exception of the Snoqualmie River above the Snoqualmie Falls, which is a barrier for migration of anadromous forms of salmonids. Chinook, steelhead and bull trout species are listed as threatened under the Endangered Species Act.

Flood-risk-reduction strategies for each basin should reflect a characterization of physical and ecological conditions, along with an evaluation of vulnerabilities that result from past development in hazard areas. Cost and benefit should also be factored into the determination of level of service. Tradeoffs may occur between cost; long-, mid- and short-term priorities in implementation; land-use densities; assessed value; and economic disruptions. King County proposes to develop a more dynamic approach to determining level of service, customized to current conditions, land uses, and basin management strategies for each planning area or river reach. Level of service will not be reduced, but may default to “maintain existing level of service.”

To better define and identify a level of service by reach, targets should be developed based on an assessment of contextual factors, such as the following:

- Physical factors—Channel width, gradient, and sediment transport, accumulation and incision
- Environmental factors—Presence of spawning or rearing habitat, riparian habitat condition
- Presence of levees or revetments
- Population at risk—Number of people who live or work in a levee-protected area
- Land uses—Types of land uses at risk, assessed value and number of structures, presence of regionally significant economic centers
- Presence of critical public infrastructure.

Structural approaches for levee and revetment reaches include the following:

- Levels of protection for levees (100-year, 200-year, 500-year)
- Cost-benefit analysis to evaluate any proposed level-of-service increase from current conditions
- Maintaining level of protection for levees
- Maintaining the prism in its current condition for levees
- Revetment designs (prevention design, resistance design)

- No reductions, but default to "maintain existing" construction, repair and maintenance.

Non-structural approaches proposed by reach include, but are not limited to, acquisition and floodplain development regulations. These are mitigation-focused approaches in areas where level of service is maintained or where no flood protection facilities are present. Examples include, but are not limited to the following:

- Prevention of locating critical facilities in the 100-year floodplain
- Limits on new development in the 100-year floodplain and severe channel migration hazard areas, in order to minimize new risks to life and property
- Acquisitions
- Elevations above base flood elevations.

King County should ensure that future development and changes in land and resource use remain in line with established levels of service. King County's Equity Impact Review tool will also be applied to each recommended target.

Structural Flood Risk Reduction Alternatives

A wide range of alternatives are available for managing King County's flood protection infrastructure. King County should seek to construct, maintain and repair flood protection infrastructure in a manner that maximizes flood risk reduction, cost-effectiveness and environmental benefit, consistent with the goals of the 2013 Flood Plan Update. This requires careful consideration of alternatives and their cumulative impacts. For structures whose benefits do not warrant continued repairs or reconstruction, abandonment or removal should be considered as well.

Alternatives are considered as part of basin, segment and reach-scale planning efforts and during the early phases of project design. They are formulated and evaluated based on procedures in the *Water and Land Resources Division Project Management Manual* (King County 2012d). Technical studies are conducted as appropriate to characterize existing conditions and to allow for a thorough comparison of alternatives, including a no-action alternative. This comparison evaluates the expected range of project outcomes immediately after construction and after the site evolves geomorphically. The comparison evaluates not only project benefits as the site evolves, but also any risks associated with site evolution, such as to adjacent or downstream properties, so that appropriate mitigation can be developed if needed.

Projects involve varying levels of stakeholder input, and an approach for engaging the community is developed as part of the initial project management plan. Projects involving the use of large wood undergo a design review for potential recreational safety risks and a public review at the preliminary design phase to seek community input on the safety of project features. This input, along with review by professional engineers, ecologists and geologists with experience in river and floodplain management, helps to create a more successful final design.

The following sections describe typical structural actions for addressing flood, erosion and channel migration hazards. They can be used independently or in combination to achieve the goals of the 2013 Flood Plan Update.

Bioengineering

Using the *King County Guidelines for Bank Stabilization Projects* adopted as a component of the *1993 Flood Hazard Reduction Plan* and more recently the *2002 Washington Integrated Streambank Protection Guidelines* and the *Stream Habitat Restoration Guidelines* prepared by Washington State Department of

Fish and Wildlife (Washington Department of Fish and Wildlife 2012c), King County has moved away from the almost exclusive use of riprap toward the use of bioengineering as the basis for nearly all repairs and retrofits on existing levees and revetments.

Levee and Revetment Abandonment or Removal

Some levees and revetments may no longer be needed following land use changes or reduced flood risk achieved by completing one or more flood hazard management activities in the vicinity. In addition, some levees and revetments are remnants of past management strategies and do not provide effective flood hazard management consistent with the policies in the 2013 Flood Plan Update. Others may be in King County's inventory for monitoring, but never have had an easement or sufficient property rights for King County to take a capital action to repair or retrofit them when needed. In locations where a levee or revetment has become obsolete, the abandonment or complete removal of that structure may be useful to help alleviate flooding risks upstream and downstream and to assist in restoration of historical fish and wildlife habitat. Abandonment or removal can be done on all or just a portion of a levee or revetment.

Abandonment involves removing a levee or revetment from King County's inventory, without physically modifying the structure. In this way, King County makes the policy decision not to repair or retrofit the infrastructure if it is damaged in the future. This requires careful consideration of how the site and river segment are likely to evolve if the levee or revetment sustains damage that would not be addressed. It also requires analysis of whether King County has any maintenance responsibility due to a contractual agreement, recent history of maintenance, or other factors. Levee or revetment removal projects will commonly be designed in coordination with other flood hazard management activities as part of an overall strategy for a river segment.

Easements

King County has over 1,000 river protection easements, which have been acquired for flood protection infrastructure construction and maintenance. River protection easements typically coincide with flood protection infrastructure locations, but numerous easements exist where flood protection infrastructure was never constructed. On the other hand, there are some areas where the County does not have a recorded easement but on which the County has historically operated and maintained flood protection infrastructure, and for which the County may have obtained prescriptive rights through historical use over time. Such areas are commonly referred to as being subject to prescriptive easements, provided certain legal criteria are met. King County cannot undertake maintenance or rehabilitation without a recorded easement or other sufficient property interest to protect the public's investment, except in rare circumstances such as during an emergency or where the County may have obtained a prescriptive easement through historical use.

River protection easements grant King County access onto and across private property for flood protection infrastructure maintenance and management. Temporary rights-of-entry are also obtained to allow for field data collection.

Most existing flood protection infrastructure easements grant King County the right to enter the property to conduct flood protection infrastructure repairs, but do not obligate King County to do so in the event of damage. This language provides King County with the ability to prioritize repairs against other flood protection capital project needs and to direct funding toward the most important and urgent projects. Projects involving reconstruction and realignment of levees and revetments may require negotiation of easements with new property owners. Depending on the project, King County may need to provide greater assurances that these new projects will be priorities for repair if they become damaged, at least over some performance period.

FLOOD HAZARD EDUCATION AND FLOOD PREPAREDNESS, FLOOD WARNING, EMERGENCY RESPONSE, AND POST-FLOOD RECOVERY

Given the amount of development that has already occurred within flood hazard areas, floods will continue to impact people and property indefinitely. In order to help minimize these impacts, King County has established four programs to help citizens and jurisdictions prepare for and respond to floods: the Flood Hazard Education and Flood Preparedness Program; the Flood Warning Program; the Emergency Response Program; and the Post-Flood Recovery Program.

In planning outreach strategies for these programs, King County will consider how best to reach historically underserved or vulnerable populations that may face barriers based on age, income, disability, language, race or other factors as part of its equity and social justice agenda.

Flood Hazard Education and Flood Preparedness Program

Brochures

King County produces and distributes a flood warning information brochure each year in English and Spanish that features the following:

- Flood warning and emergency response services
- Flood phase explanations and impacts for each river
- Recommendations for flood insurance and personal preparedness
- Important phone numbers and Web addresses for information and assistance.

The brochure is mailed to about 5,000 property owners and addresses located in unincorporated King County floodplains, and is distributed through local libraries and the cities within these floodplains.

The pamphlet, *Before, During and After a Flood*, developed with Public Health—Seattle & King County, King County Office of Emergency Management, the Local Hazardous Waste Management Program in King County, and the King County Flood Control District, provides preparedness and response information in English and Spanish to help floodplain residents reduce flood-related risk, damage and provide contact numbers for more information.

Annual Outreach to Repetitive Loss Properties and Floodplain Residents

Each year, King County mails an informational letter and the flood warning information brochure to all owners of repetitive loss properties and owners of floodplain properties in unincorporated areas of King County, as identified by FEMA Flood Insurance Rate Maps. The letters are in English, with a sentence offering interpretation services in two dozen commonly spoken languages. These mailings make property owners and residents aware of the flood hazards likely to affect their property, highlight programs and projects available to help them reduce flood-related risks, describe steps they can take to protect themselves and reduce flood damage, and provide contact numbers for more information.

King County Flood Website

King County's Flooding Services Web page, www.kingcounty.gov/flood, consistently ranks as one of the most visited pages of the King County website. This site hosts extensive and detailed information about flood preparedness and local flooding conditions, including the following:

- 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
- King County's flood protection infrastructure
- Home buyout and elevation program information
- A flood mapping application to assist in determining whether properties are within a 100-year floodplain, a CMZ or other hazard area
- Flooding documents, such as the *King County Flood Hazard Management Plan*.

In addition to the links identified in the adopted 2006 Flood Plan, the website links to iMap, at www.kingcounty.gov/iMap. 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.

King County Television and Social Media

Public service announcements about flood preparedness information and services and special emergency conditions appear on King County Television (KCTV) and via King County's social media channels, such as Twitter, Facebook and Flickr.

Outreach to Vulnerable and Underserved Populations

King County has an on-call interpretation service during regular business hours to take calls from residents who speak limited or no English or to provide this service in the Flood Warning Center during a flood event. In addition, flood preparedness and safety videos are available on the King County Flood Services Web page, at www.kingcounty.gov/floodservices, in the top 21 languages spoken in King County and American Sign Language. The videos are also posted on YouTube.

All written materials are translated into Spanish routinely, and into other languages as needed. Some materials are translated into the most commonly spoken languages in King County.

Improved communication coordination with Public Health—Seattle & King County, Office of Emergency Management, and the American Red Cross Serving Kitsap and King County is improving the ability to reach underserved populations. For example, flood preparedness information is routinely shared with Public Health's Community Communication Network, made up of more than 100 community-based organizations, many of which serve vulnerable populations

Flood Warning Program

Flood Warning Center

The Flood Warning Center is the center of operations for the Flood Warning Program during flood events. The flood emergency director activates the Flood Warning Center whenever one or more rivers reach Phase II of the four-phase flow-based flood warning alert system illustrated in Figure 4-1. At Phase III or greater, or at the flood emergency director's discretion, field inspection teams are sent out by the Flood Warning Center to monitor flood protection infrastructure and investigate potential flood risks.

The Flood Warning Center works with King County public information officers, who issue press releases frequently during flood events and work with local media outlets to provide accurate information to the public. Press releases are posted on the King County and Regional Public Information Network websites and transmitted through the Regional Public Information Network and Twitter via Web-based messaging, with on-call interpretation services if needed to accommodate limited or non-English speakers. The Flood Warning Center website provides real-time river gage data and other flood warning and preparation information. An automated, interactive voice-response phone message system with similar content is available year-round.

Figure 4-1

KING COUNTY FLOOD WARNING PHASE THRESHOLD AND FLOOD PEAK SUMMARY

2013 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE

Phase	Tolt River (near Carnation)	Snoqualmie (Sum of Forks)	Issaquah Creek (near Hobart)	Cedar River (Landsburg)	Green River (Auburn)	White River (near Buckley)
I	2,500 cfs	6,000 cfs	6.50 ft	1,800 cfs	5,000 cfs	5,000 cfs (Unless COE or NWS calls with specific info)
II	3,500 cfs	12,000 cfs	7.50 ft	2,800 cfs	7,000 cfs	8,000 cfs
III	5,000 cfs	20,000 cfs	8.50 ft	4,200 cfs	9,000 cfs	10,000 cfs
IV	8,500 cfs	38,000 cfs	9.00 ft	5,000 cfs	12,000 cfs	12,000 cfs

RECENT LARGE FLOOD PEAKS

Tolt River (near Carnation)	Snoqualmie (Sum of Forks)	Issaquah Creek (near Hobart)	Cedar River (Landsburg)	Green River (Auburn)	White River (near Buckley)
11,400 cfs 11/29/95	48,280 cfs 11/24/90	9.90 ft 11/24/90	10,800 cfs 11/24/90	11,500 cfs 11/24/90	14,100 cfs 1/9/90
11,800 cfs 12/15/99	53,500 cfs 11/6/06	9.73 ft 2/8/96	6,580 cfs 11/30/95	12,400 cfs 2/8/96	13,200 cfs 12/1/95
13,800 cfs 1/8/09	54,110 cfs 1/7/09	8.86 ft 1/8/09	7,870 cfs 1/8/09	12,200 cfs 11/7/06	11,700 cfs[1] 11/9/06 and 1/9/09

[1] Based on Corps data on flow releases from Mud Mountain Dam.

File name: 1208_2636fhmpFIG413.ai wgab

Flood Alert System

Early flood warning notifications are critical in providing additional time for property owners, floodplain occupants and those responsible for their safety to respond to flood threats. The Flood Alert System was implemented to quickly and simultaneously send voice calls, text messages and emails to anyone who chooses to receive notifications. Messages are sent by King County staff using a software service when reliable river data is received that meets or exceeds Phase II, III and IV thresholds on individual rivers. Additionally, messages may be sent with flood-related emergency information. The following is an example of a flood alert message.

> "The Snoqualmie River has reached flood phase 2. Minor flooding is expected in low-lying areas. More information at www.kingcounty.gov/flood or 1-800-768-7932"

Subscribers can sign up for free flood alerts on a King County website or by phone:

- http://www.kingcounty.gov/environment/waterandland/flooding/warning-system.aspx
- 206-263-3400.

Subscribers have options to receive alerts regarding six different river systems using three separate phase thresholds on multiple phone, text and email contacts. Other agencies offer emergency notifications, including the U.S. Geological Survey. King County's flood alert website provides information on various notification systems to assist the public in selecting the services that are best suited to their needs.

Multiple public outreach efforts are ongoing to encourage the public to sign-up for flood alerts. Currently the system has over 5,000 subscribers.

Coordination With Other Agencies

The Flood Warning Center works closely with The King County Office of Emergency Management, the Road Services Division, local jurisdictions 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 and Seattle Water Department regarding dam operations.

The National Weather Service office in Seattle is another critical partner in the flood warning process, working with the King County Flood Warning Center and other partners in the overall mission of helping protect lives and property. The National Weather Service maintains weather surveillance and forecasting responsibility for most of western Washington and issues warnings for many types of hazards, including floods, severe weather, windstorms, snowstorms and fire conditions.

The National Weather Service issues a Flood Potential Outlook statement when heavy rain is expected to cause flooding or aggravate existing flood conditions. Flood Potential Outlook statements are generally issued two to three days before the potential event. National Weather Service Flood Watches for specific areas and rivers are issued one to two days before an event. National Weather Service Flood Warnings are issued up to one day in advance when flooding is imminent. This applies to a specific river forecast point that is expected to exceed a flood stage based on predictive computer river modeling output, including dam operation information, and to other streams and urban areas.

National Weather Service statements are communicated to state and local agencies and the media through the National Oceanic and Atmospheric Administration Weather Wire and using satellite-based systems. For the largest storms and major floods, the National Weather Service conducts direct Internet briefings and uses follow-up phone calls to King County. National Weather Service statements and information are

communicated to other government agencies and the public via National Oceanic and Atmospheric Administration Weather Radio, radio and television, the Internet, telephone recordings and newspapers.

Public Sandbag Distribution

Sandbags, when used properly, can reduce damage from flooding. King County helps to provide sandbag materials to the public free of charge through a partnership with nine local cities—Auburn, Carnation, Duvall, Kent, North Bend, Pacific, Seattle, Snoqualmie and Tukwila—and one community group, the Fall City Community Association. Most of the cities purchase sand and sandbags before the flood season and distribute the materials at public works facilities. King County provides funding and materials to support the program. Occasionally King County will support additional sandbag distribution events. The Flood Warning Center provides information to the public regarding sandbag availability as follows:

- Online at http://www.kingcounty.gov/environment/waterandland/flooding/sandbag-distribution.aspx
- Through an automated phone message system, at 206-296-8200 or 800-945-9263,
- Receiving phone calls to the Flood Warning Center.

Emergency Response Program

A presidential major disaster declaration authorizes a wide range of programs for recovery, including financial assistance to public agencies, loans for individuals, families and small businesses, loans for farmers and ranchers, financial assistance grants, and housing grants. A presidential emergency declaration provides more limited assistance. Major disaster assistance is provided through regional FEMA centers and the state. No presidential emergencies have been declared in King County; 12 presidential major disaster declarations related to flooding have been made since 1990.

Post-Flood Recovery Program

Post-flood recovery is generally the final step in responding to a flood event as property owners and jurisdictions take actions to return their lives to normal following a flood event. The recovery process includes immediate actions, such as recording high water marks and conducting inspections, and longer-term actions such as seeking financial assistance and making repairs. All of these actions are necessary to assess damage, restore services and make repairs quickly and permanently. Several King County departments play a role in post-flood recovery, with much of the overall coordination provided by the King County Office of Emergency Management. Coordination can be improved to streamline efficiencies in service delivery.

Recording High Water Marks

Immediately following a flood event, the height of the floodwaters is generally evident through high water marks on the side of buildings and through the deposition of mud and debris along the banks of streams and rivers. Property owners are generally quick to hose down their buildings and clean up the debris, but by doing so without recording these high water marks there is a loss of valuable information that can be used to prepare for future flood events. This information is important because when combined with other quantifiable data, such as river and stream discharge measurements, property owners can have a better prediction of how future flood events may impact their property. In addition, this information can often be used when calculating the benefit vs. the cost of a flood mitigation project by comparing the cost to elevate a home to the estimated damage that would be avoided based on depths of flooding calculated from these high water marks. High water marks can be recorded in many ways, including photographs, permanent marks on buildings or a measurement above known elevation. Ideally, high water marks are surveyed so that they can be used to calibrate flow models and be compared with floodplain maps.

King County has recorded high water marks on public infrastructure and public land following flood events, but does not routinely do so. There are costs associated with staff time for gathering the information, assessing the data, and storing it in a usable format. King County needs to have a better understanding of how this information can be used before committing to recording high water marks on public infrastructure and property. The value of this information may vary from river basin to river basin, based on the overall basin mitigation strategy developed from the hydrology, hydraulics, geomorphic characteristics and land use.

Debris Removal and Disposal

During flood events, a wide range of debris is washed downstream; as floodwaters recede, this material is deposited along river banks and on the upland areas of the floodplain. Sometimes debris collects in areas where floodwater conveyance channels are constricted, such as bridge abutments or along river banks where trees that have fallen into the channel trap debris washing downstream. Debris removal policies and protocols vary based on whether the debris is natural material, such as large pieces of natural wood that can be beneficial to fish and wildlife, or material that would meet the definition of solid waste or special waste. King County will rely on the policy guidelines contained in Policy RCM-1 and Policy RCM-2 on when and how to reposition or relocate large wood in river corridors following a flood event.

In all cases, solid waste and special waste material must be removed from the channel and floodplain and disposed of in approved disposal sites. Property owners whose buildings and contents are damaged by floodwaters are often overwhelmed by the amount of flood-damaged material that needs proper disposal. King County Council has generally approved fee waivers for disposal of flood debris at King County solid waste transfer stations or landfill. Debris collection stations have traditionally been established in communities hardest hit by flooding. Following the January 2009 flood event, more than 790 tons of debris was collected in 10 days following the flood event. King County should continue to work with property owners to ensure that flood-related debris is removed and disposed of properly.

Post-Flood Damage Inspections

King County and partner agencies conduct post-flood inspections of critical flood protection infrastructure to assess damage. It is essential to return this critical infrastructure to functional operation as soon as possible to avoid major disruptions to the delivery of health and safety services and restore the regional economy as soon as possible.

King County Road Department inspects flood damage to roads and bridges. King County Water and Land Resources Division inspects damage to critical levees, revetments, pump stations and other flood infrastructure. These inspections are used to generate cost estimates that can be used when seeking funding under the FEMA Public Assistance Program or planning the King County Flood Control District’s work program and budget.

King County Department of Assessments conducts inspections to determine the extent of damage to real and personal property. Both state and King County Code provide property tax relief for property damaged by flooding or other natural disasters. The property must be located in an area that has been declared a disaster by the governor or the County.

King County Department of Permitting and Environmental Review inspects buildings in unincorporated King County to determine the level of damage and the required standard for repair. King County Code Chapter 16.06 defines level of repair for buildings and structures damaged by a disaster that was declared an emergency at the county level. This inspection assists property owners and the County in defining building code standards that will need to be met when repairs are made. Inspections are also conducted

within incorporated cities to assess the level of damage and to assist property owners with post-flood repairs.

The Department of Permitting and Environmental Review should also conduct inspections following a flood event to determine if a property has been substantially damaged. While King County does not define substantial damage, both federal and state flood regulations have specific provision related to repair and replacement of structures that have been substantially damaged in mapped floodplains. Substantial damage is defined as damage that is equal to or greater than 50 percent of the market value of the structure. Federal law prohibits repair of a substantially damaged building in the FEMA floodway if that repair results in any increase in the flood elevations. State code prohibits repair or replacement of substantially damaged residential structures in the FEMA floodways except for residential structures in the agricultural production district and residential structures that can meet a specific depth and velocity standard to ensure that the structure is not located in a portion of the FEMA floodway with deep, fast flows. King County needs to determine the level of damage to a building in order to accurately implement the code. These inspections have not been routinely conducted due to inadequate staffing levels and the department's fee-supported financial structure.

By identifying properties that have been substantially damaged, King County can help property owners who carry flood insurance qualify for increased cost of compliance flood insurance claims. This money is used specifically to assist property owners with flood mitigation projects, such as home elevations or relocations. When combined with FEMA grant funding, property owners with substantially damaged homes can use their increased cost of compliance funding to pay a substantial amount, or in some cases all of their out-of-pocket expenses for their mitigation projects.

Public Health—Seattle & King County oversees recovery efforts to ensure that people are not subject to health hazards resulting from contaminated floodwaters, mold from flood-damaged buildings, or other health-related problems.

FEMA Public Assistance Program

Following a federal presidential emergency declaration or presidential major disaster declaration, FEMA implements the Public Assistance Program to help local governments, tribal nations and non-profit organizations recover from natural disasters and declared emergencies. The Public Assistance Program provides disaster funding for projects such as debris removal, emergency protective measures, and the repair, replacement or restoration of disaster-damaged public infrastructure such as roads, parks, utility lines and flood protection infrastructure that is not the responsibility of a federal agency, such as the U.S. Army Corps of Engineers or the Federal Highway Commission. Applicants for the Public Assistance Program must demonstrate that they are eligible for the program, that the emergency work performed was eligible, that the structure was damaged as a result of the declared disaster or declared emergency, that the project to repair or replace the damaged structure is eligible, and that the cost of the repairs is reasonable. The Public Assistance Program also includes environmental review of proposed repairs and can assist with funding required fish and wildlife habitat mitigation work.

The King County Office of Emergency Management coordinates collection of damage data to support the request for disaster relief funding under the Public Assistance Program. King County has experienced varying degrees of success in obtaining Public Assistance funding following a major disaster declaration. One of the major challenges has been to demonstrate that the damage is a result of the declared flood event and is not unrepaired damage from an earlier flood. King County is establishing an inspection, monitoring and adaptive management program that will provide the baseline information and data to demonstrate that King County is maintaining and inspecting its flood protection infrastructure and to document the pre-flood condition of flood protection infrastructure.

Another challenge has been that King County often chooses to upgrade damaged infrastructure to meet contemporary design guidelines, such as incorporating habitat features into the project. While the Public Assistance Program does authorize upgrades necessary to meet specific requirements of current codes and standards, it generally only provides funding to repair the damaged infrastructure to the pre-damage design, which may be flawed and will result in continued future damage. The Public Assistance Program does authorize alternate projects in lieu of repairing the damaged structure. However if the damaged structure is repaired, Public Assistance funding may not provide funding for habitat elements that King County must provide to maintain consistency with the Endangered Species Act and the Clean Water Act.

FEMA has often denied funding based on the claim that it cannot adequately inspect the flood protection infrastructure due to vegetation encroachment. FEMA deploys supplemental staff from around the country to help conduct inspections following a natural disaster. Some of these inspectors have not experienced floodplain management practices used in jurisdictions whose floodplains and riparian corridors contain species and habitat listed under the Endangered Species Act or Magnuson-Stevens Act, which require vegetation to provide habitat for listed species. This lack of understanding of the importance of a vegetated riparian corridor has resulted in FEMA denial of Public Assistance funding.

Once funding is awarded, there are additional challenges finding agreement with FEMA on project designs. If a flood structure is not repaired, it becomes ineligible for future funding under the Public Assistance Program. Consequently King County needs to establish specific criteria to determine when to seek Public Assistance funding and when to pay for the repairs from local funds.

Given the challenges of participating in the Public Assistance Program, King County will continue to assess on a case-by-case basis whether participation is consistent with sound and sustainable floodplain management practices and other federal laws.

Repairing Damaged Flood Protection infrastructure

Following a flood event, King County uses the policies contained in Chapter 2 of the 2006 Flood Plan to determine whether damaged flood protection infrastructure should be repaired. If emergency repairs were made during a flood event, the conditions under which the emergency repair was authorized may require that the project be rebuilt to meet current design guidelines and mitigate for habitat impacts that may have resulted from the emergency actions.

Key policies that King County uses when completing flood protection infrastructure repairs include identifying whether the site is within the geographic scope of the 2006 Flood Plan , as specified in Policy G-1. The infrastructure must provide some level of protection from the flood risks defined in Policy G-2 and must meet the multiple benefit objectives in Policy G-3. Finally, King County should prioritize and sequence flood repairs to address flood and channel migration risks using the scoring criteria for flood risk and project implementation, attached in Appendix K.

River Safety Risk Reduction

King County modifies rivers through capital projects to achieve flood risk reduction and other regional goals. Some capital projects encourage more dynamic river processes by reconnecting floodplains and increasing flow conveyance capacity. Such projects may result in substantial changes in river environments during large flood events, or incrementally over time. Physical changes resulting from river projects aimed at flood risk reduction may affect in-river recreational users who have previously used less complex and dynamic channels. Though these changes are viewed differently by different user groups, some river recreational users may face increases in hazards due to changed river conditions. River recreation is inherently dangerous, and King County cannot eliminate river hazards; but the County should work to minimize increased risk caused by its actions.

The 2006 Flood Plan addressed public safety and risk reduction in rivers through discussion of the management of natural wood and the use of wood for erosion control and stability in bioengineering projects. Since that writing, King County has actively worked to clarify, improve and document public safety considerations, procedures and policies around the management of natural wood in rivers, and the use of wood in constructed projects.

In 2009, King County convened the Large-Wood Stakeholder Committee to address concerns regarding the safety of recreational river users as they relate to large wood. The committee's *Final Report and Recommendations*, published in October 2009, summarized the ecological, historical and regulatory context for large-wood management and made recommendations to King County in three key areas:

- Enhanced outreach and education to recreational river users is necessary to help users reduce their own personal risks by promoting thoughtful planning, preparation and decision-making.
- Stakeholders should be offered predictable, meaningful and transparent involvement related to large-wood placement projects.
- Policies, roles and procedures for responding to reports of hazardous naturally occurring wood should be clarified.

In 2010, the King County Department of Natural Resources and Parks adopted Public Rule LUD 12-1, *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers*. This rule documented the County's procedure of identifying safety considerations at the preliminary design phase of County-sponsored riverine capital projects intended to use placed large wood. Procedures were outlined for involving stakeholders. Monitoring and adaptive management of projects is required, as is an independent review of placed-wood projects. King County Ordinance 16581, which required the public rule, also required that a committee of stakeholders be convened at least every three years to review and update the policy. King County is the only local government known to have such requirements, and these procedures are only applicable to projects sponsored or funded by the Department of Natural Resources and Parks, which includes projects implemented on behalf of the District.

In 2009, King County embarked on a pilot study in the Cedar River to describe the location, character, functional value and potential flood-related risks associated with large-wood accumulations. In 2010, a related pilot study was conducted to characterize recreation use on the lower reaches of the Cedar River, looking at the type and amount of in-water recreation, locations of uses, risk factors and awareness of users. In 2011, King County conducted telephone and Web-based surveys to better understand public values and attitudes about rivers and river management options. These studies provided a better understanding of river users and the risk-oriented choices they make. This information is beneficial to project designers, resource managers and public safety officials.

King County is continuing to develop policy and program improvements that achieve flood risk reduction goals in a way that considers the safety of recreational users and responsibly manages the costs of safety-oriented measures. Capital programs are committed to implementing standardized project management practices for all phases of capital projects, as well as regular inspections, monitoring, maintenance and adaptive management. In addition, the County is committed to engaging with stakeholders at both the basin and project levels regarding goals, expected outcomes, the degree of inherent uncertainty and the possibility of unexpected outcomes.

The methods that King County uses to build and manage projects in the river environment do not address every aspect of public safety. A large factor in safety risks of recreational users involves the knowledge, skill, experience and level of hazard awareness of the individual person involved in recreational activity. Personal decisions regarding how and when one chooses to recreate, how to prepare, and what equipment

to use or leave behind, as well as training and physical abilities, all play an essential role in reducing or eliminating hazards. While King County cannot be responsible for individual decisions related to recreational river use, there may be a role for public agencies in promoting informed choices. King County government has several departments that work to inform the public about the inherent hazards of rivers, with the goal of increasing public perception of associated risks and promoting a better informed public with regard to risk-reducing personal choices. These departments include Executive Services, Natural Resources and Parks, Public Health, and the Sheriff's Office.

CHAPTER 5.
COUNTYWIDE AND BASIN-SPECIFIC CHARACTERISTICS

Chapter 5 of the 2006 Flood Plan outlines countywide projects and programs and provides a basin by basin description of flood conditions along each of the major rivers in King County. It also presents proposed actions to reduce or eliminate risks associated with these hazardous conditions. Updates in the 2013 Flood Plan Update include new information on flood protection facilities, major flooding and flood damage; key accomplishments since adoption of the 2006 Flood Plan (Appendix D); and identified risks. For additional countywide and basin-specific information on geology and geomorphology, hydrology and hydraulics, ecological context, salmonid use, flood hazard management objectives and strategies and proposed actions, refer to the 2006 Flood Plan.

COUNTYWIDE PROJECT AND PROGRAM UPDATES

Countywide programs and projects to be implemented across all basins include flood preparedness, emergency response, flood protection infrastructure maintenance, flood hazard studies and mapping, flood hazard planning and public outreach, countywide opportunity funds for emergency repair of flood protection infrastructure, and residential flood hazard mitigation analysis and implementation.

Table 5-1 lists proposed countywide programs. These generally focus on the collection, use and dissemination of information on an annual or nearly annual basis, but also include routine maintenance of flood protection infrastructure and public outreach programs. These programs will be implemented by the River and Floodplain Management Section of King County's Water and Land Resources Division, as the service provider for the Flood Control District. Cost estimates for implementing these programs are presented as annual costs and as the estimated cost over the six-year period from 2013 through 2018.

TABLE 5-1.
PROPOSED COUNTYWIDE PROGRAMS AND COST ESTIMATES, 2013 - 2018

Proposed Action	Description	Annual Costs	6-Year Estimate
Flood Preparedness, Warning and Emergency Response, and Recovery	Implement a comprehensive approach to preparing and educating citizens about flood events, coordinating emergency response and regional Flood Warning Center operations during flood events, and ensuring consistency across basins for post-flood recovery actions.	$675,000	$4,049,000
Resource Management, Annual Maintenance, and Flood Protection Infrastructure Assessment Program	Perform maintenance for approximately 500 levees and revetments along 119 miles of riverbank, over 600 acres of floodplain-managed property, three pump stations, and related flood protection infrastructure. Carry out annual routine maintenance, including flood protection infrastructure mowing, noxious weed control, installation and repair of access controls, and minor repair and maintenance of flood protection infrastructure and related properties and appurtenances. Develop and implement a flood protection infrastructure inventory database and a routine program of inspection, condition assessment, and monitoring for all levees, revetments, raised banks, pump stations, stormwater discharge structures, cross-culverts, closure structures and appurtenances.	$1,912,000	$11,472,000

TABLE 5-1.
PROPOSED COUNTYWIDE PROGRAMS AND COST ESTIMATES, 2013 - 2018

Proposed Action	Description	Annual Costs	6-Year Estimate
Flood Hazard Studies, Mapping, and Technical Services Program	Implement a sediment management program that includes expanded channel monitoring, establishment of thresholds to trigger actions, and analysis of sediment management action alternatives. Conduct flood hazard studies and floodplain and channel migration zone mapping. Provide floodplain management technical support to all King County departments proposing activities or projects that affect floodplain functions.	$573,000	$3,437,000
Public Outreach, Flood Hazard Planning and Grants, and Repetitive Loss Mitigation	Carry out public outreach on floodplain management programs and projects, and respond to inquiries and complaints from citizens and from public and private agencies. Maximize federal, state and local funding opportunities through grant applications in support of completing capital improvement projects, technical studies and other flood hazard management activities. Provide supporting documentation, technical support and staff training required to maintain favorable status in FEMA's Community Rating System.	$660,000	$3,962,000
King County Flood Control District Implementation	Implement flood hazard management programs and capital improvement projects for the District. Coordinate with King County cities through Basin Technical Committees, which consist of jurisdictions' technical staff and 15-member advisory committees of elected officials. Provide technical support to King County's Department of Permitting and Environmental Review for floodplain permits and inquiries, floodplain mapping, elevation certificates, and Critical Areas Ordinance updates. Provide floodplain management technical support to Snohomish, Cedar, Green and White River watershed coordination and salmon habitat recovery activities. Administer Sub-Regional Opportunity Fund and WRIA Collaborative Watershed Management Grant programs	$3,609,000	$21,653,000
Program Management and Supervision; and Finance, Budget, and General Administration	Provide for program administration, staff supervision and training, flood hazard management plan updates, Comprehensive Plan Consistency, and the River and Floodplain Management Section Annual Report	$2,337,000	$14,024,000
Total Countywide Programs		**$9,766,000**	**$58,597,000**

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SOUTH FORK SKYKOMISH RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

The primary King County flood protection facilities along the South Fork Skykomish River line most of the left riverbank and several hundred feet of the right bank through the Town of Skykomish. This includes training levees and revetments intended to hold the channel in place and resist bank erosion; most are not containment levees designed to prevent overbank flooding. There are also several levees and revetments along the South Fork Skykomish in the Baring area and along the lower Miller River.

The largest flood on record on the Skykomish River at Gold Bar occurred in November 2006; this flood inundated the Town of Skykomish along the South Fork Skykomish River. After the November 1990 event, many levees and revetments throughout the South Fork Skykomish basin were damaged and rebuilt with traditional rock riprap installations; these repairs have held up well. Subsequent to the November 2006 flood, a portion of the left bank levee in the Town of Skykomish downstream of the bridge was completely rebuilt.

In January 2011, a section of the lower Miller River avulsed and severed a 150-foot section of the Old Cascades Highway. The river channel is now west of its former alignment under the Miller River bridge. King County Road Services Division has determined that replacement of this road is not feasible.

Table 5-2 summarizes the highest flow records at the South Fork Skykomish River at Gold Bar.

TABLE 5-2.
HIGH FLOW RECORDS AT SOUTH FORK SKYKOMISH RIVER AT GOLD BAR

Date of Flood	Peak Flow (cubic feet/second (cfs))
November 2006[a]	129,000 cfs
December 1995	79,600 cfs
November 1990	102,000 cfs
November 1986	76,500 cfs

a. Largest flood on record

Key Accomplishments Since the 2006 Flood Plan

Since 2006, several properties in areas at high risk for erosion or inundation have been purchased. These include three houses in Timber Lane Village and four parcels constituting a monastery on the Miller River alluvial fan. A repair of the McKnight Revetment on the right bank of the South Fork Skykomish in Baring, which was damaged in the 2009 flood event, was completed in 2011.

King County River and Floodplain Management Section staff have assisted King County Roads in assessing options for addressing the damage to the Old Cascades Highway at the avulsion site on the Miller River alluvial fan.

Flood Hazard Management Identified Risks

King County has mapped historical channel locations of the South Fork Skykomish. The area where historical channels are located can be particularly hazardous for flooding and erosion. King County also recently evaluated areas of flood inundation and identified community areas along the South Fork Skykomish with buildings exposed to inundation.

Based on this preliminary review, about 75 houses appear to be located within the area of historical channel locations, which indicates high levels of present-day channel migration hazards. More than half of these are in the Baring community area, within the subdivisions of Montagna Park, Skylo Park, Riverwood Park, Skylandia and Chamonix Village. In addition, a few residences in the Town of Skykomish and in the Timber Lane Village subdivision appear to be located within the area of historical channel locations.

The preliminary evaluation also indicated that more than 40 homes in the Town of Skykomish are likely subject to inundation. Preliminarily, 13 or more homes appear to be exposed to 2 feet or more of flood depth on the first floor at the 100-year flood elevation. Another 10 or more homes upstream of the Town of Skykomish, near the mouth of the Beckler River, also appear to be subject to these flood depths.

Inundation hazard overlaps partially with erosion hazard, particularly in the Riverbend Park and Skylandia subdivisions in the Baring area, in Timber Lane Village upstream of the Town of Skykomish and within the Town of Skykomish. Because these three community areas have both erosion and inundation hazards, they are considered to be the areas within the river corridor with the most significant flood hazard conditions.

SOUTH FORK SNOQUALMIE RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Flood protection facilities along the South Fork Snoqualmie River include a system of continuous levees through North Bend and several discontinuous levees and revetments up and downstream of the levees. There are 28 levees or revetments in the South Fork Snoqualmie River corridor, making up about 9 miles of armored riverbank. With the exception of the lower 2 river miles of the South Fork Snoqualmie, most outside river bends are armored up to river mile 9.1.

High flows overtop the banks and flood the neighborhoods of Circle River Ranch and Shamrock Park. The January 2009 event did not have record flows on the South Fork Snoqualmie, but flows were high enough to overtop the levee, inundating 19 homes. Damage occurred to numerous levees or revetments during this flood event: Circle River, Bendigo Lower Right, Bendigo Upper Left, Bendigo Upper Right, Si View Park, Reif Road, Si View, Holstein Extension, Riverbend, Stanley Carlin and Allen. Water over 415th Way Southeast caused road closures.

A major flood in 2006 and minor floods in 2010 and 2011 also caused damage to King County levees and revetments in this area. Table 5-3 summarizes the largest flows at the U.S. Geological Survey's South Fork Snoqualmie gage in North Bend, USGS gage 12144000. Table 5-4 summarizes the highest flows recorded at the South Fork Snoqualmie above Alice Creek near Garcia gage, USGS gage 12143400.

TABLE 5-3. HIGH FLOW RECORDS AT SOUTH FORK SNOQUALMIE GAGE IN NORTH BEND, USGS GAGE 12144000

Date of Flood	Peak Flow (cfs)
January 2009	12,300 cfs
November, 2006	13,600 cfs
November 1990	10,900 cfs
December 1977	12,400 cfs
December 1975	12,600 cfs

TABLE 5-4. HIGH FLOW RECORDS AT SOUTH FORK SNOQUALMIE ABOVE ALICE CREEK NEAR GARCIA GAGE, USGS GAGE 12143400

Date of Flood	Peak Flow (cfs)
November, 2006	8,450 cfs
November 1990	8,000 cfs
November 1986	8,450 cfs

Key Accomplishments Since the 2006 Flood Plan

Between 2006 and 2013, King County completed seven flood protection infrastructure repairs, including one as an emergency action during the 2010 flood season. Si View and Reif Road levees in the Leveed segment of the river and Allen and Riverbend revetments farther upstream have been repaired. The November 2006 and January 2009 events created sinkholes and cavities in the top of the levee prism that have since been repaired.

Ten homes in the Shamrock Park neighborhood have been elevated so that the first floor living space is above the 100-year flood elevation. One home has been purchased and demolished. Three additional home elevations are planned in Shamrock Park and four in the Clough Creek neighborhood.

A geomorphic hazard and risk assessment for the Circle River Ranch neighborhood has been completed to inform flood risk reduction actions in the river's Snoqualmie Valley Trail to Confluence segment. One home in the Circle River Ranch neighborhood has been purchased and demolition plans are underway.

The *South Fork Snoqualmie Gravel Removal Study* (King County 2011) considered the impacts of gravel accumulation on flood levels, as well as the potential effectiveness of gravel management actions. The results are being considered during preliminary design for the South Fork Snoqualmie Levee Improvement project.

Preliminary geotechnical and hydraulic analysis for the South Fork Levee Improvement project have been completed and design work including development of a suite of alternative actions to be developed and analyzed is underway. This updated technical information is being used to quantify the benefits of various potential floodplain management actions. Landowner and stakeholder input will help guide selection and sequencing of potential actions to reduce flooding impacts and improve habitat in the Leveed Section beyond the detail provided in this 2013 Flood Plan Update.

Flood Hazard Management Identified Risks

The following are the flood hazard management risks identified for this river:

- Risks to public safety from deep, fast flows
- Risks to public and private infrastructure, including drainage systems, streets and buildings
- Potential impacts on the regional economy if the City of North Bend is severely flooded
- Risks to private structures, both residential and commercial
- Potential for all of these risks to worsen suddenly in the event of a levee failure.

MIDDLE FORK AND NORTH FORK SNOQUALMIE RIVERS UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

The flood protection facilities on the Middle Fork Snoqualmie and North Fork Snoqualmie consist of a system of discontinuous levees and revetments. There are 13 levees and revetments on the Middle Fork Snoqualmie and 10 on the North Fork Snoqualmie; 3.4 miles of riverbank are armored in some fashion. The original construction methods and materials used to build most of these are unknown.

Flood flows in 2009 damaged several levees: Shake Mill Left, a private flood control structure, and Vallcuda on the North Fork Snoqualmie; and Mason Thorson Extension and Mason Thorson Ells on the Middle Fork Snoqualmie. Most of this damage was subsequently repaired. This flood event also caused overtopping of several roads, including Southeast Middle Fork Road and Southeast Lake Dorothy Road. The Shake Mill Left levee was damaged again by floods in 2010 and 2011.

Table 5-5 summarizes the highest flows recorded at the Middle Fork Snoqualmie gage. Discharge was estimated at nearly 50,000 cubic feet per second for the December 1959 flood, before the gage was installed, which would be the largest flood on the Middle Fork Snoqualmie since settlement times (Perkins 1996). The North Fork Snoqualmie gage has a long, nearly continuous data collection history dating to 1930. Table 5-6 summarizes the highest flows recorded at the North Fork Snoqualmie gage.

TABLE 5-5.
HIGH FLOW RECORDS AT MIDDLE FORK SNOQUALMIE GAGE

Date of Flood	Peak Flow (cfs)
January 2009	31,200 cfs
November 2006	31,700 cfs
November 1990	30,100 cfs
December 1977	30,200 cfs
December 1959	~50,000 cfs

TABLE 5-6.
HIGH FLOW RECORDS AT NORTH FORK SNOQUALMIE GAGE

Date of Flood	Peak Flow (cfs)
January 2009[a]	17,100 cfs
November 1995	14,500 cfs
November 1959	13,400 cfs
January 1945	13,400 cfs
October 1934	13,400 cfs

a. Largest flood on record

Key Accomplishments Since the 2006 Flood Plan

Between 2006 and 2013, King County completed five repairs on Mason Thorson Extension and Mason Thorson Ells levees and relocated three hazard trees. King County has completed early planning of a comprehensive strategy for flood hazard management along the Middle Fork Snoqualmie. This early work included analyzing and monitoring the Mason Thorson Extension levee. An emergency action plan was developed, to be used in response to potentially rapid changes at the site. Additional assessments were initiated to characterize geomorphology, hydraulics, hydrology, habitat conditions and land use that influence the Middle Fork Snoqualmie corridor. Since 2006, three properties have been acquired with King County Flood Control funds, totaling 8.8 acres.

Preliminary geomorphic, hydraulic and ecologic existing conditions analysis for the Middle Fork Corridor Management Project have been completed and design work including development of a suite of alternative actions to be developed and analyzed is underway. This updated technical information is being used to quantify the benefits of various potential floodplain management actions. Landowner and stakeholder input will help guide selection and sequencing of potential actions to reduce flooding impacts and improve habitat in the Leveed Section beyond the detail provided in this 2013 Flood Plan Update.

Flood Hazard Management Identified Risks

The following are the flood hazard management risks identified for this river:

- Risks to public safety from deep, fast flows
- Risks to public infrastructure, including drainage systems, streets, and buildings
- Potential impacts on the regional economy if the City of North Bend is severely flooded
- Risks to private structures, both residential and commercial
- Potential for all of these risks to worsen suddenly in the event of a levee failure, channel avulsion or relocation.

UPPER SNOQUALMIE RIVER MAIN STEM UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

There are 19 levees and revetments in the Upper Snoqualmie basin, representing 2.6 miles of armored riverbank. Six of those are on Kimball Creek and 13 are on the Upper Snoqualmie. The levees and

revetments are discontinuous, but most outside river bends are armored. Historical aerial photos and file materials indicate that most of this flood protection infrastructure was constructed or significantly improved in the mid-1960s.

The major flood event in January 2009 and minor floods in 2010, 2011 and 2012 caused damage to several levees and revetments: Record Office, Meadowbrook, and the 202 to Mouth Left Revetment on Kimball Creek. The Record Office and Meadowbrook revetments have been repaired. The January 2009 flood event caused widespread damage to public and private property in the City of Snoqualmie and surrounding unincorporated area of Kimball Creek. King County Roads Division closed Southeast Mill Pond Road and Southeast Reinig Road in January 2009 and the City of Snoqualmie issued evacuation orders during this flood event.

Table 5-7 summarizes the highest flows recorded at the Upper Snoqualmie gage. According to U.S. Geological Survey staff, the November 1990 record discharge appears too high with respect to other gages in the Snoqualmie basin, although the U.S. Geological Survey does not have enough evidence to remove the computed discharge from published flow records.

TABLE 5-7.
HIGH FLOW RECORDS AT UPPER SNOQUALMIE GAGE

Date of Flood	Peak Flow (cfs)
January 2009	60,700 cfs
November 2006	55,000 cfs
February 1996	51,700 cfs
November 1990	78,800 cfs
November 1986	58,100 cfs
December 1977	53,800 cfs
December 1975	51,800 cfs
November 1959	61,000 cfs

Key Accomplishments Since the 2006 Flood Plan

Between 2006 and 2013, King County and the City of Snoqualmie collaborated to elevate 39 homes with FEMA grant funding—23 through the City of Snoqualmie's program and 17 by King County. The City of Snoqualmie has secured FEMA grant funding for an additional 39 home elevations for which King County is contributing 12.5 percent in matching funds. Additionally, King County, with FEMA grant funds, has completed six property acquisitions totaling 4.2 acres, removing 22 residences from areas of high flood and channel migration hazards, including the Riverside Mobile Home Park.

The completion of the mitigation needs assessment through the Upper Snoqualmie Valley Residential Flood Mitigation Project has led to a programmatic strategy for home elevations and acquisitions. More than 230 residential structures in this river segment have first floor elevations below the 100-year flood elevation and are candidates for non-structural flood mitigation projects.

Two revetment repairs have been completed since 2006. King County responded to 21 flood events.

Flood Hazard Management Identified Risks

The following are the flood hazard management risks identified for this river:

- Risks to public safety from inundation and deep and erosive flows
- Risks to public infrastructure, including drainage systems, streets and buildings
- Potential impacts on the regional economy if the City of Snoqualmie is severely flooded
- Risks to residential and commercial private structures
- Risks to three public schools
- Potential for all of these risks to worsen suddenly in the event of a levee failure.

LOWER SNOQUALMIE RIVER MAIN STEM UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

There are 126 levees and revetments in the King County River Flood Protection Facility Inventory along the Lower Snoqualmie River from the Tokul Creek confluence at River Mile 37.7 to the King and Snohomish county line at River Mile 5.5. This flood protection infrastructure is generally discontinuous and often located on the outside of meander bends, but sometimes the infrastructure lines both banks of the river to confine and limit lateral migration. Many of these levees and revetments originated as privately constructed bank protection along farm properties many decades ago. Two flood control bonds passed in the 1960s funded additional construction and dozens of flood protection infrastructure improvements. Most of the Lower Snoqualmie levees were not intended to provide significant containment of flood flows, and none of these levees provides containment for the 100-year flood. They function more as revetments, providing bank hardening and some resulting limitation to bank erosion and channel migration.

Other flood control infrastructure, constructed or maintained by other agencies or private entities, exists in a number of locations along the Lower Snoqualmie and is not part of the King County inventory. One such revetment, along the right bank of the river upstream of the State Route 202 bridge in Fall City, is maintained by the Washington State Department of Transportation to protect the state highway alignment and the approach to the bridge. A similar bridge approach protection was constructed in 2010 by the King County Department of Transportation on the right bank of the river just upstream of the N.E. Carnation Farm Road bridge. Additional, significant bank protection revetments of unknown history, constructed to protect agricultural areas, remain in a number of locations in the Lower Snoqualmie River corridor.

Flood protection infrastructure that was damaged during the November 2006 and January 2009 events includes the McElhoe Pearson and Aldair levees and the Sinnema Quaale and Winkelman revetments. State Route 202 was overtopped in January 2009 just upstream of the Raging River confluence, causing scour damage to the road and several residences, two beyond repair. The January 2009 event also caused extensive damage to farms, including scour of farm fields, damage to barns, fences and other structures, and deposition of debris and sediment on fields. The 2006, 2008 and 2009 flood events caused overtopping and closures of a number of State and County roads in the valley. Roads that were damaged by these or other flood events in the past include State Routes 202 and 203, N.E. Woodinville-Duvall Road, N.E. Carnation Farm Road, and Neal Road S.E.

Table 5-8 summarizes the highest flows on the Snoqualmie River in recent history, as recorded at the Snoqualmie River near Carnation gage. While these events produced widespread flooding and damage, several other moderate flow events between 2006 and 2012 caused additional damage.

TABLE 5-8.
HIGH FLOW RECORDS AT LOWER SNOQUALMIE RIVER NEAR CARNATION GAGE, USGS GAGE 1214900

Date of Flood	Peak Flow (cfs)
January 2009[a]	82,900 cfs
November 2008	63,100 cfs
November 2006	71,800 cfs
November 1990	65,200 cfs

a. Largest flood on record

Key Accomplishments Since the 2006 Flood Plan

Since January 2006, structural accomplishments in the Lower Snoqualmie River corridor include repairs to two levees. The McElhoe Pearson levee was damaged during the November 2006 flood event and was repaired through the U.S. Army Corps of Engineers' Public Law 84-99 program in the summer of 2008. The levee was damaged again during the November 2008 flood event and was repaired in the summer of 2009. The Aldair levee was repaired in 2008 due to damage caused during the high flows of November 2006. Large capital projects have been initiated to address damage at the Sinnema Quaale Upper and Winkelman revetments.

Non-structural accomplishments in the Lower Snoqualmie valley include home and barn elevations, property acquisitions, and technical and permitting assistance for the construction of farm pads for agricultural properties. Ten homes and two barns have been elevated since January 2006. King County shared elevation project costs on six of these structures as part of the Snoqualmie 205 flood reduction project. Additional non-structural accomplishments since 2006 include the acquisition of five properties with 15 residences on 36 acres; four of these properties are in the high-risk location where State Route 202 was damaged during the January 2009 flood. The County also provided technical and permitting assistance for construction of 24 farm pads. These non-structural actions supporting farmers, and other regulatory changes that have occurred, implement a number of recommendations included in the 2008 Snoqualmie Flood-Farm Task Force Report.

Programmatic accomplishments since January 2006 include ongoing channel monitoring in addition to updating flood hazard mapping. Portions of the Lower Snoqualmie segments below the Raging and Tolt rivers are study reaches in the Snoqualmie gravel study that is in progress under King County's ongoing channel monitoring effort. The study is evaluating the amount and rate of sediment deposition, the degree to which it is influencing flood elevations, and the degree of reduction in flood elevations that could be accomplished with gravel removal.

Hazard mapping in this basin includes detailed flood studies and Flood Insurance Rate Maps along the main stem Snoqualmie. Updated Flood Insurance Rate Maps were submitted to FEMA in May 2006 (Northwest Hydraulic Consultants 2006). These maps are not yet formally adopted but are used in practice as the best available science. More detailed floodplain modeling is being conducted in the Snoqualmie at Fall City segment as part of a capital project feasibility planning effort. While this modeling will not modify Flood Insurance Rate Maps or regulatory water surface elevations or boundaries, it will enhance the technical understanding of flooding conditions in the segment and inform analysis and comparison of potential actions to reduce flood hazards.

Channel migration zone mapping has not been done on the Lower Snoqualmie and will be prioritized among countywide flood and channel migration zone mapping needs.

Flood Hazard Management Identified Risks

Basinwide

The Lower Snoqualmie River main stem has a broad valley where flooding of agricultural, residential and commercial properties typically occurs valley wall to valley wall. While a network of levees and revetments provides varying levels of flood protection and resistance to bank erosion and lateral channel migration, flood hazards exist across nearly the entire floodplain. Farms, roads, homes and businesses scattered throughout the hazard area are at risk, as even moderate events, such as a 10-year flood, can cause extensive flooding and inundate nearly the same extent of the floodplain as larger floods. Approximately 87 percent of the floodplain consists of the Snoqualmie Agricultural Production District. The river is also home to Chinook salmon, steelhead trout and bull trout that are listed as threatened under the Endangered Species Act.

A significant project in the Upper Snoqualmie basin has influenced flood levels to at least a minor extent throughout the Lower Snoqualmie corridor. The Snoqualmie Flood Reduction Project, or Snoqualmie 205, was a cooperative project between the U.S. Army Corps of Engineers, the City of Snoqualmie and King County completed in 2004 and 2005 to reduce flooding in the City of Snoqualmie. This project included modifications to increase conveyance in the river channel just upstream of Snoqualmie Falls. This increased upstream conveyance and associated loss of flood storage likely increased flood flows downstream of the falls. A downstream impact analysis conducted as part of the project design determined that any rise in water surface elevations associated with the increased peak flows would be minor—on the order of 0.1 foot or less for flood events up to and including the 100-year flood. A downstream assistance program was initiated as part of the project to provide financial support for structure elevations in affected areas. Impacts of the completed project have not been documented.

Snoqualmie Falls to Fall City

This segment is relatively steep and narrow in its upstream end; flooding and erosion hazards occur primarily in the residential and commercial areas where the floodplain broadens upstream of the Raging River confluence east of Fall City. This segment has the highest recreational use in the Lower Snoqualmie.

Alluvial Fan Segments: Snoqualmie at Fall City and Snoqualmie at Carnation

The alluvial fans of the Raging and Tolt rivers and related sediment deposition make these segments more dynamic fluvial process areas, where attempts to control the river have been more costly and had greater environmental impacts. Flood protection infrastructure in these segments has required more frequent repairs, resulting in more rock placed and more trees removed. Overbank flooding and high-velocity, erosive flows occur in these sections of the river valley due to the steeper gradient. Fall City and Carnation are located on the alluvial fans of the Raging and Tolt rivers, respectively. Agricultural uses dominate downstream of Fall City, and north and south of Carnation. These segments of the main stem, and the lower segments of the Raging and Tolt rivers, are the highest priority for Chinook salmon spawning and rearing.

Meander Segments: Patterson Creek to Tolt River and Chinook Bend to County Line

The Snoqualmie River in these segments meanders through a broad, low-gradient section of the valley where oxbows and wetlands are common. Flooding across the valley is frequent, even during smaller

floods, though flows are typically lower-velocity. The dominant land use is agricultural. Nearly all of the floodplain within these segments is in the Agricultural Production District. Flooding becomes progressively deeper in the north end of the valley, in the vicinity of Duvall.

TOLT RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Carnation Segment

The main King County flood protection facilities on the Tolt River are the nearly continuous levees and revetments along both sides of the lower 2 miles of the river. Built in about 1940, these facilities provide varying levels of flood containment through the Carnation segment. The greatest level of flood containment is provided along both banks upstream of the Snoqualmie Valley Trail bridge; there is less containment from the bridge to State Route 203, with areas of overtopping at flow levels below the 10-year flood. Overall, the Tolt River levees in the Carnation segment do not provide protection to the 100-year flood. However, the levee system has limited channel migration and avulsions in this segment.

Upstream of the Snoqualmie Valley Trail bridge, the left bank levee between River Mile 1.4 and River Mile 2.0, referred to as the Girl Scout levee, is the upstream part of the Tolt levee system on the river's left bank. This levee disconnects historical channel locations and floodplain and limits channel migration to the south toward the Girl Scout Camp River Ranch. There is potential for avulsion upstream of the levee, which could increase erosion and flood hazards to the levee and to the property behind it.

The Frew Upper and Holberg levees, on the right bank upstream of the Snoqualmie Valley Trail bridge, provide critical flood protection infrastructure for protecting the City of Carnation from flooding. The Holberg levee was reconstructed in 1995, greatly reducing the flood risk to the City of Carnation from this location. The flood containment function of the Holberg levee ends at River Mile 1.8, but bank protection continues upstream along a side channel known as the North Channel to River Mile 2.1. This revetment along the North Channel is the sole protection for 10 homes built within the mapped CMZ; however, it is not an effective barrier to channel migration.

The Snoqualmie Valley Trail bridge frequently collects large wood during floods, possibly contributing to increased flood depths upstream of the bridge and scour of the bridge piers. Elevated water surface elevations introduce increased flood risk into the City of Carnation over the right bank levee, the Frew Upper levee. This condition represents an ongoing need for emergency debris removal.

Downstream of the Snoqualmie Valley Trail bridge, the left bank neighborhood served by N.E. 32nd Street between State Route 203 and the Snoqualmie River Trail bridge is only marginally protected from flooding and erosion by a levee of questionable structural integrity, the Highway to Railroad Bridge levee. This levee was overtopped and breached during the January 2009 flood event. In addition to causing floodwater inundation and access restrictions, the levee breach damaged multiple residences on N.E. 32nd Street, some beyond repair. The right bank levee in this reach was also damaged at River Mile 1.0 during the January 2009 flood.

Downstream of the State Route 203 bridge, where Snoqualmie River backwater and overbank flow can have as much of an effect on flooding as the Tolt River itself, there is negligible flood containment. Widespread flooding occurs even during smaller flood events. The left bank levee downstream of the State Route 203 bridge is believed to exacerbate main stem Snoqualmie River flooding upstream of the confluence of the two rivers.

In January 2009, the Carnation segment levees were significantly damaged at six locations and experienced minor damage at a number of other locations. State Route 203 was overtopped north of the Tolt River bridge during this event. The overtopping reduced access to Carnation during the flood and resulted in damage to the highway. Minor damage to Tolt River levees also occurred as a result of moderate flood events in 2010 and 2011.

Ongoing sedimentation occurs within the full length of the Carnation segment due to its location on the Tolt River alluvial fan, a natural depositional area. Historical flood management practices included removing gravel from the channel within the Carnation segment, especially by dredging the Tolt River delta at the Snoqualmie River. This practice has been discontinued since the 1960s. Ongoing sedimentation is likely reducing the flood containment capacity of the levees. This is being evaluated as part of the Snoqualmie channel monitoring studies.

Upstream of Carnation Segment

Dynamic channel processes continue in the absence of significant structural barriers in the Upstream of Carnation segment. Just downstream of River Mile 3 on the right bank, a King County levee contiguous with a King County revetment protect the Tolt River Road and a few residential properties. Flood protection infrastructure in a number of other locations was constructed or is maintained by private entities. The San Souci neighborhood is currently afforded limited protection by a private informal structure constructed in the early 1990s, but is still at risk from flooding, erosion and channel migration.

In January 2009, a major avulsion occurred between River Mile 2.5 and River Mile 3.5, within the existing severe channel migration zone. The Tolt River main stem relocated from the east to the west side of the floodplain, reoccupying a former channel alignment.

Table 5-9 summarizes the highest flows in recent history on the Tolt River, as recorded at the Tolt River near Carnation gage.

TABLE 5-9.
HIGH FLOW RECORDS AT TOLT RIVER NEAR CARNATION GAGE

Date of Flood	Peak Flow (cfs)
January 2009	13,800 cfs
December 1999	11,800 cfs
November 1995	11,400 cfs

Key Accomplishments Since the 2006 Flood Plan

Since 2006, structural accomplishments in the Tolt River corridor include emergency repairs to the Highway to Railroad Bridge and Frew levees during the January 2009 flood and repairs to damage and an accompanying setback of the Tolt River Road Protection revetment later in 2009.

Additional structural work included repairs to the Snoqualmie Valley Trail bridge, including scour protection for the mid-channel bridge piers that were damaged in January 2009 and replacement of the timber trestle approach span on the left bank that had significant fire damage. The trestle was replaced with a new bridge approach span supported by deep foundation piles. This new approach span foundation allows for flow expansion and an increased extent of channel migration under future-project scenarios that include setting back the left bank levees upstream and downstream of the bridge.

The Lower Tolt River Floodplain Reconnection Project was a levee setback project on the right bank downstream of the State Route 203 bridge that was completed in 2009 in a cooperative effort between King County and the City of Seattle. The project facilitated significant floodplain reconnection, giving the Tolt and Snoqualmie rivers access to 45 acres of floodplain that had been previously disconnected by the Tolt River levee system.

Since 2006, the following properties have been acquired with King County Flood Control District and salmon recovery funds:

- 12 properties in the San Souci Neighborhood, including 12 residences and 40 acres
- 10 properties at the Tolt River Mile 1.1 Setback site, including 8 residences and 7 acres
- 1 residence on 1 acre at the Tolt Natural Area Floodplain Reconnection site.

Ongoing monitoring since 2006 includes a gravel study of the lower 1.72 river miles of the Tolt River. This section of the Tolt River is a study reach in the Snoqualmie gravel study that is in progress as a part of King County's ongoing channel monitoring effort. The study is evaluating the amount and rate of sediment deposition, the degree to which it is influencing flood elevations, and the degree of reduction in flood elevations that could be accomplished with gravel removal.

The Tolt River Corridor Action Plan was initiated in 2010. This effort includes updating available technical information about the existing physical conditions of the river and quantifying the benefits of various potential floodplain management actions. Potential effects of levee setback projects on the City of Carnation, such as changes in the 100-year flood elevation, will also be assessed as a part of this effort. Landowner and stakeholder input will help guide selection and sequencing of potential acquisitions, levee setback projects, and other actions to reduce flooding impacts and improve habitat in the Tolt River corridor beyond the detail provided in this 2013 Flood Plan Update.

Flood Hazard Management Identified Risks

Flood and erosion risks in the Upstream of Carnation segment include bank erosion, channel migration, avulsion, landslides, inundation, and cut-off access. Properties at risk include residences, small businesses, and small agricultural operations, as well as public and private roads and other infrastructure.

Flood and erosion risks in the Carnation segment are related to its location on the Tolt's alluvial fan and the levees that line most of this section of river. Levees can be overtopped or incur damage, leading to flooding and erosion of homes, businesses and farms in the City of Carnation and unincorporated King County.

RAGING RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

The main King County flood protection facilities on the Raging River are continuous levees constructed in the late 1930s that run along both sides of the river in the Fall City segment from the 328th Way S.E. bridge at River Mile 1.5 to the mouth. Areas adjacent to the Raging River at its confluence with the Snoqualmie River are subject to flooding from both the Raging and Snoqualmie rivers. This flooding is most prevalent on the Raging River right bank near the Snoqualmie confluence, where flooding frequently forces the evacuation of a campground used throughout the flood season. The Raging River levees downstream from the 328th Way S.E. bridge limit channel migration across the Raging River alluvial fan and provide variable levels of flood containment.

Although the existing levees downstream from the 328th Way S.E. bridge are higher than the 100-year flood elevation in some areas, they neither provide this level of protection in all areas nor have sufficient freeboard to be federally certified. Extreme high flows or a levee breach on the left bank in this reach would result in floodwaters flowing north from the Raging River through Fall City toward the Snoqualmie River. Ongoing sediment accumulation in the Raging River channel, particularly from the Preston-Fall City Road bridge at River Mile 0.5 to the mouth, may diminish future flood capacity and increase flood hazards on both sides of the Raging River. Sedimentation from the Raging River at its delta could have similar effects locally along the Snoqualmie River.

Upstream of the continuous levee system in the Fall City segment, there are 14 additional flood protection structures in the County's inventory, most of which are revetments. These protect roads and residences up to about River Mile 8 but are subject to damage from bank erosion and channel migration. Other flood protection infrastructure, constructed or maintained by other agencies or private entities, exists in a number of locations upstream of the Fall City segment.

Most of the development upstream of Fall City is sparse, but a mobile home park and several single-family residences just upstream of I-90 could suffer substantial damage if an avulsion were to occur through undeveloped property immediately upstream of the mobile home park. Despite several revetments in this reach—some in the County inventory and others not—evidence of erosion suggests that such an avulsion could occur. An avulsion during the November 2006 flood event, and subsequent lateral migration, undermined and destroyed a home at River Mile 5.7.

Major damage was caused to levees in all three river segments on the Raging River in November 2006: Arruda, Bryce, Bridge to Bridge Left, Bridge to Bridge Right, Bridge to Mouth Right, and Preston Fall City Lower. The flood of January 2009 resulted in moderate damage to levees in the I-90 to Fall City segment: Preston Fall City Lowest, Preston Fall City Lower, Preston Fall City Upper and 312th Avenue S.E. The Upper Preston Road just downstream of the Alpine Mobile Manor was damaged during the November 2006 flood event. Table 5-10 summarizes the highest flows in recent history on the Raging River, as recorded at the Raging River near Fall City gage.

TABLE 5-10.
HIGH FLOW RECORDS AT RAGING RIVER NEAR FALL CITY GAGE, USGS GAGE 1214900

Date of Flood	Peak Flow (cfs)
November 2006	4,310 cfs
January 1990	4,640 cfs
November 1990[a]	6,220 cfs
November 1986	5,330 cfs

a. Largest flood on record

Key Accomplishments Since the 2006 Flood Plan

Structural accomplishments along the Raging River since 2006 include seven repairs to six revetments and levees to address damage sustained in the 2006 and 2009 flood events: Arruda, Bryce, Bridge to Bridge Left, which received two repairs, Bridge to Bridge Right, Bridge to Mouth Right, and Preston Fall City Lower.

More than 1,000 feet of the Carlin levee in the I-90 to Fall City segment was removed in 2006. The levee removal allows the river to migrate laterally across the previously inaccessible floodplain. Nine groups of large boulders placed on the left floodplain edge protect the Preston Fall City Road from lateral scour while maintaining channel and floodplain roughness and complexity.

Non-structural accomplishments since 2006 include the acquisition of six properties in the Alpine Mobile Manor neighborhood in the Upstream of I-90 segment, comprising five residences and 8 acres.

Programmatic accomplishments since 2006 include ongoing channel monitoring of the lower 1.5 river miles of the Raging River. This section of the Raging River is a study reach in the Snoqualmie gravel study that is in progress and is a part of King County's ongoing channel monitoring effort. The study will evaluate the amount and rate of sediment deposition, the degree to which it is influencing flood elevations, and the degree of reduction in flood elevations that could be accomplished with gravel removal.

Flood Hazard Management Identified Risks

There are 6.5 miles of river above the Fall City segment at high risk for channel migration, bank erosion, and, in some locations, avulsion. Properties at risk include residences in the Channel Migration Zones (CMZ) and floodplain, as well as public roads, including the Preston-Fall City Road. These segments are important habitat for federally listed salmonids and other fish and wildlife.

In the Fall City segment, flooding risk is related to levee overtopping, damage or failure. Flood and erosion risks in the Fall City segment are related to its location on the Raging River's alluvial fan and the continuous levees that line both banks throughout the segment. Levees can be overtopped or incur damage, leading to flooding and erosion of homes and businesses in the unincorporated town of Fall City. This segment contains important spawning and rearing habitat for federally listed Chinook salmon and other fish and wildlife.

SAMMAMISH RIVER, ISSAQUAH CREEK, LAKE WASHINGTON TRIBUTARIES UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Sammamish River

The entire Sammamish River acts as flood protection facility following channel straightening, deepening, and bank armoring in the mid-1960s. The flood control project was designed to reduce the frequency and severity of spring flooding, which, prior to channelization, often destroyed newly seeded row crops. Most of the flood protection consists of rock-lined banks that are flush with the adjacent grade at the top. The U.S. Army Corps of Engineers' flood control project for the Sammamish River also included improved conveyance of the lower ends of Bear Creek in Redmond, Little Bear Creek in Woodinville and North Creek in Bothell. Easements extending 22 feet from the top-of-bank line both sides of the river's 14-mile length. During the 1970s, public ownership was acquired for a trail system along much of the river's length. This easement extends landward 50 to 100 feet from the top of the riverbank.

A weir at the uppermost end of the river functions to retain water in Lake Sammamish at a higher level during summer, when the lake is used heavily for recreational activities. 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, a significant portion of the total 14-foot drop over the entire river.

There have been a series of structural modifications since 1964. In 1998, King County partnered with the U.S. Army Corps of Engineers 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.

The 1964 Sammamish River operation and maintenance manual outlines maintenance practices to ensure conveyance of the design flow through the river channel. Under these practices, the channel and its banks were expected to be kept free from any feature that would impede the conveyance of flood flows. As initially interpreted, this meant 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.

Maintenance practices have since evolved to reflect subsequent environmental regulations and awareness. In 2002, King County and the U.S. Army Corps of Engineers jointly developed the Sammamish River Action Plan, which articulates a vision for multi-objective management along the length of the river. 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, keeping up with mowing the invasive plants that dominate the river's banks is neither practical nor necessary from a flood perspective. However, in 2011 the frequency and extent of mowing in the transition zone was increased in response to elevated lake levels. In addition, trimming of the willow buffer was increased to maintain a navigation channel and flow conveyance.

Major river flooding has become an infrequent occurrence since the river was deepened and straightened. Table 5-11 summarizes the largest flood events in the present-day channel, measured at USGS gage 12125200 near Woodinville.

TABLE 5-11.
HIGH FLOW RECORDS AT SAMMAMISH RIVER NEAR WOODINVILLE GAGE, USGS GAGE 12125200

Date of Flood	Peak Flow (cfs)
Dec 2005 – Jan 2006	1,770 cfs
January 1997	2,870 cfs
February 1996	2,470 cfs
January 1986	2,320 cfs
March 1972	2,390 cfs

Issaquah Creek

Flood protection infrastructure along Issaquah Creek is fairly minimal, consisting of short sections of riprapped banks for streambank protection. Management of that infrastructure typically involves post-flood repairs to restore damage. Much of Issaquah Creek within the Issaquah city limits has hardened banks—the result of past farming and urban development—and significant failures are rare.

Along Issaquah Creek, flooding historically was mostly confined to farmlands, and the farm properties were only minimally affected by high water. Early newspaper accounts generally wrote of flooded

farmlands, washed out roads, and an occasional flooded basement. However, as development progressed to the edges of the streams and bridges were built for roads, flood impacts and damage increased. Flooding now affects urban areas of Issaquah that were farmland until only a few decades ago, impacting commercial and residential properties alike.

The recent history of significant flooding along Issaquah Creek and Tibbetts Creek began in December 1975 with a flood event that was then called the largest since 1933. Subsequent major floods occurred in November 1986, January and November 1990, February 1996, and January 2009. Flood insurance payments for the January 2009 flood event totaled $1.75 million. The 1996 flood had similar damage. Total FEMA payout for flood insurance claims within the city from 1978 through 2011 was $3.9 million. Commercial properties in the Gilman Square area of Issaquah accounted for about 40 percent of all historical flood insurance claims.

Lake Washington Tributaries

The slope of Lyon Creek flattens out as it reaches the commercial core of Lake Forest Park, where it is funneled into several culverts before passing under State Route 522. The culverts are undersized relative to current-day flows, causing the creek to backwater and spill over into adjacent McAleer Creek and flooding the entire area. Significant public infrastructure and critical facilities are affected, including the fire station, the community center, and the primary highway through this area. Also flooded are over 20 single-family homes in the Sheridan Beach neighborhood. Major flooding is persistent, with three 100-year events in the past 20 years. The most recent flood caused approximately $4 million in damage. The flood resulted in the closure of two lanes of the highway, and the fire station remained closed for many months.

Coal Creek is fed by stormwater runoff from multiple jurisdictions. The lower end of the creek was channelized and subsequently developed for residential use in the area formerly occupied by the alluvial delta. Lower Coal Creek currently flows from a regional detention facility at I-405, then passes through levee-lined banks and numerous culverts intended to safely convey flows through the densely populated residential neighborhood. The detention facility is a 20-acre-foot, in-channel detention pond, owned and operated by the City of Bellevue. The facility temporarily stores the stream behind a dam-like impoundment that doubles as the road prism for I-405. This facility helps reduce peak flows, but none of the flood protection structures—the detention pond, levees or culverts—have sufficient storage or flow capacity to protect the surrounding neighborhood during a 100-year flood event.

The problems are exacerbated by the fact that the creek transports a significant amount of sediment, much of it generated from the loose soils of a former coal mine near its headwaters. Ongoing streambed aggradation in the lower reach dramatically reduces conveyance capacity. Connection of the local storm drainage system contributes additional flooding in the neighborhood when backwater conditions occur. Once floodwater escapes the stream corridor, it can flow laterally down streets, often threatening homes, including homes not adjacent to the creek. Preliminary hydraulic modeling predicts that many homes are at risk of structural flooding, especially when the flow control facility is at full stage. Since 1995, there have been approximately 65 individual reports of flooding and flood damage.

Key Accomplishments Since the 2006 Flood Plan

In recent years, King County and the cities of Redmond, Woodinville, Bothell and Kenmore have engaged in a number of projects to enhance the Sammamish River corridor for aesthetic, recreation, and fish and wildlife habitat functions. These include reshaping the banks, replacing invasive plants with native species along the river’s banks, installing instream large wood and bar features, and reshaping straightened sections of channel. The projects were designed such that flood conveyance was protected.

Recent concerns arose regarding the potential impact of greater vegetation retention in the transition zone, as it could affect water levels around the Lake Sammamish shoreline. Homeowners on the lake indicated that the lake's water surface elevations appeared to be rising over time. In response, King County conducted a study of Lake Sammamish outflow to the Sammamish River. The study demonstrated that there has been an increasing trend in lake water surface elevation over the past decade, which could not be clearly attributed to changes in Issaquah Creek inflows or precipitation effects. While vegetation in the Sammamish River transition zone was not definitively identified as the cause of the lake water surface elevation increase, it was demonstrated through modeling and empirical data collection that increasing maintenance actions to remove or thin vegetation in that area could increase lake outflow to the river during moderate winter flows.

In response to these findings, King County worked with homeowners to develop the April 2011 *Lake Sammamish Flood Reduction Plan*, which recommended several short and long-term strategies to improve understanding and management of the river as it relates to lake outflow, including increased maintenance and a feasibility study of sediment removal. Additional early monitoring results indicate that short-term steps successfully improved conveyance and navigability through this reach. Next steps include an aquatic weed removal trial. Working toward a more long-term solution for management of the transition zone, King County and the City of Redmond have engaged in a partnership to conduct a feasibility study for the Willowmoor Floodplain Restoration Project. The study will identify alternatives for reconfiguring the transition zone to improve fish and wildlife habitat conditions while maintaining flood control objectives.

On Issaquah Creek, the City of Issaquah has made significant progress with projects to mitigate flood problems. Severe bank erosion from the 2009 flood that threatened a city road and the Medical Center of Issaquah was addressed in a 2010 bank stabilization project funded and constructed cooperatively with the landowner. The Squak Valley Park South Restoration Project, constructed in 2010, involved property acquisition and partial removal of a streamside levee to reduce flood elevations in the Sycamore neighborhood. Other acquisitions have included an additional 12.2 acres in the Issaquah Creek basin since 2006, permanently removing these areas from flood risk. As a result of these and previous property acquisitions, the City of Issaquah has preserved about 100 acres of floodplain as permanent open space. This amounts to about 26 percent of the entire 100-year floodplain within the city limits.

In 2010 the City of Issaquah was awarded funding from the FEMA Flood Hazard Grant Program to elevate six flood-prone homes to current floodplain standards. As of 2012, five homes have been elevated; the sixth home identified in the grant was transferred to a FEMA Severe Repetitive Loss grant and will be elevated in 2013.

Flood Hazard Management Identified Risks

Sammamish River

Flood risks are minimal in the Sammamish River basin, largely because of past flood risk reduction efforts. As a result of the flood control project in the 1960s, Sammamish River flooding is infrequent, is generally limited to agricultural and recreational fields, and is usually not fast or deep. Riverbank failure is limited to small localized areas of slumping. There are only two FEMA repetitive loss properties. Many current land uses in the Sammamish River floodplain, such as recreation and agriculture, are largely compatible with infrequent, short-term, and low-velocity flooding. However, ongoing development continues, potentially reducing flood storage areas throughout the watershed, and increasing runoff volumes and peak flows.

While the channelization of the Sammamish River has greatly reduced flood risks in the Sammamish River and around Lake Sammamish, ecological considerations were not taken into account in

development of the flood control project or its maintenance practices. The most significant outcome has been the loss of streamside vegetation and instream complexity that provide necessary food, shade and cover for fish and wildlife. Occasionally, parts of the river have been dredged or cleared of sediment and wood deposits. The river corridor has also experienced an onslaught of invasive species, including Himalayan blackberry, reed canary grass, and English hawthorn trees, which have come to dominate the banks of the river, thriving in the full sun environment created by historical riverbank clearing practices. The wholesale clearing of streamside trees and shrubs and instream wood and sediment has led to severely degraded habitat and water quality.

Dredging and vegetation clearing activities are now being closely monitored by the Muckleshoot Indian Tribe Fisheries Division and environmental groups who have expressed strong concern that changes in vegetation cover and flow management may negatively impact a river with an already impaired temperature condition. All future dredging or vegetation management efforts will need to consider impacts on water quality and salmon habitat and weigh those impacts against flood benefits.

Issaquah Creek

The middle and upper reaches of Issaquah Creek, which flows out of the foothills of the Cascade Mountains, are dominated by rural residential and forested lands; the lower reach runs through the City of Issaquah. Flood impacts are most notable in the city, which contains 20 of the 23 FEMA-identified repetitive loss properties in the basin.

Lake Washington Tributaries

The *Lower McAleer and Lyon Creek Flood Reduction Study* recently completed by the City of Lake Forest Park offers two alternatives for addressing flooding problems in the commercial hub. One solution involves constructing a high-flow bypass pipe on Lyon Creek to divert flood flows directly into Lake Washington from a point upstream from where the creek currently overtops. The second option involves constructing setback berms on both public and private property and upgrading existing culverts, to provide additional conveyance capacity for flood flows.

Reducing peak storm flows and enhancing stream channel conveyance capacity while maintaining or improving aquatic habitat are thought to be the key methods for addressing the flooding problems along Lower Coal Creek. Potential capital projects, which could be constructed alone or in combinations, include increasing the storage volume in the regional detention facility, increasing conveyance capacity of the culverts, increasing the height of the earthen berms, constructing a high-flow bypass pipeline, redirecting the local storm drainage system away from Coal Creek and connecting it directly to Lake Washington, and strategic acquisition of at-risk properties. As a first step to resolving the flooding problems on Lower Coal Creek, an engineering feasibility study will be conducted to identify alternatives and determine which approach is most cost-effective. The goal is to provide flood protection up to the 100-year flow event. The selected alternative will seek to achieve flood protection improvements in a way that maintains fish passage and enhances riparian and floodplain habitat conditions.

CEDAR RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Since the 1960s, King County has constructed 65 structures for flood and erosion control in the Lower Cedar River valley. Despite decades of attention to maintenance of these levees and revetments and channel clearing practices, flooding and flood damage continue throughout the basin. This is the result of limited previous understanding of local flood hazards, inconsistencies in coverage, lack of design and

construction standards, deterioration of older flood protection infrastructure, and an increase in the number of homes and infrastructure in flood hazard areas. Over time, King County's levees and revetments and the homes and lands they protect will become more vulnerable to damage. Further, the techniques used to build and maintain these flood protection structures may make salmon habitat recovery efforts difficult.

In 1998 the City of Renton participated in a U.S. Army Corps of Engineers 205 Flood Control Project that resulted in removal of gravel and construction of floodwalls and levees along the reach of the Cedar River passing through the City of Renton. This was a substantial project that protects critical infrastructure that is important to the regional and state economy, including the Boeing Renton Plant and the Renton Airport. The 205 Flood Control Project structures are maintained by the City of Renton through an agreement with the U.S. Army Corps of Engineers.

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. As of 2011, 19 homes in the Cedar River basin were identified by FEMA as repetitive loss properties based on flood insurance claims. Of these, 12 have been mitigated by purchase or home elevation. Many other homes that lack flood insurance are known to have experienced repeated flood damage as well.

Damage to levees and revetments from the 2009 event was estimated to be $3.1 million. An unknown amount of damage was sustained by other public infrastructure, such as roads, bridges and utilities, as well as private property. Many homes were surrounded by deep, fast flows, numerous roads became impassable, homes and furnishings were destroyed, wells were contaminated, and some residents were forced to access their homes by rowboat. Parts of the City of Renton, including the Renton Municipal Airport and industrial properties, were flooded during the 1990 flood but received little flood damage in 2009, largely as a result of the dredging and levee construction in this reach.

Table 5-12 summarizes the record floods on the present-day Cedar River. Major floods also occurred in 1975, 1995 and 1996, resulting in similar public and private damage and losses. Additional floods in 2006 and 2011 were of moderate magnitude, but also caused damage to levees and revetments as well as homes, infrastructure and other properties.

TABLE 5-12.
HIGH FLOW RECORDS AT CEDAR RIVER AT LANDSBURG GAGE

Date of Flood	Peak Flow (cfs)
January 2009	7,870 cfs
November 1990	10,800 cfs

Key Accomplishments Since the 2006 Flood Plan

King County has completed 25 major flood hazard management projects on the Cedar River since 2006, as well as several programmatic actions that reduced the risks of flood hazards. Projects have included three emergency repairs during major flood events, 17 major retrofits and repairs to flood protection infrastructure, five minor flood damage repairs, two levee setbacks, and buyouts of flood-prone homes. Programmatic actions included studies and public outreach efforts to improve citizens' understanding of local flood hazards and how to protect themselves and minimize personal damage.

Flood protection infrastructure repairs have used biotechnical bank stabilization techniques to retrofit and repair 2,850 linear feet of riverbank. These projects have integrated native vegetation and large wood into

the structure in a way that strengthens the flood protection infrastructure and improves habitat value. The branching vegetation and large wood features slow localized velocities, reducing erosion, while the root system binds the soil increasingly over time. Overhanging vegetation and in-water structures provide food, cover and refuge for fish and wildlife. An additional 2,730 linear feet of levee have been reconstructed in a setback configuration, reconnecting 31 acres of floodplain for absorption of flood flows and habitat restoration.

In many neighborhoods along the Cedar River, the flood risk to residents cannot be eliminated through the construction of flood protection infrastructure, and buyout and relocation of homes may provide the best solution for eliminating repeated flood damage and safety risks. King County has acquired 90 flood-prone homes in the Cedar River basin through an ongoing voluntary home buyout effort, including a 51-unit mobile home park located in the river's floodway and 11 of the 19 FEMA-identified repetitive loss properties. Together, these acquisitions have opened up 116 acres of floodplain for natural functions. Many are key properties needed for larger-scale high-priority flood hazard reduction projects in the basin. These acquisitions not only reduce flood risks, but also create opportunities for partnerships for long-term restoration and stewardship of these lands. After acquisition, all structures on each property are demolished, the site is stabilized and revegetated using native plant species, and all lands are maintained as open space in perpetuity. The benefit of these flood hazard management projects has been increased through coordination with the WRIA 8 Salmon Recovery Council, multiple King County agencies, cities, and community-based groups. These coordination efforts led to the acquisition by the City of Seattle of six additional homes flooded during the January 2009 flood event. The city plans to restore these lands as part of its habitat conservation plan.

Major programmatic accomplishments in the Cedar River basin focused on reducing risk by improving the technical understanding of flood risks and sharing this information through outreach and education:

- A recently completed study of channel migration mapping methodologies will assist in the preparation of channel migration zone maps for the Cedar River. King County will use the new maps in selecting and prioritizing flood hazard mitigation projects and regulating future development that would be at risk due to channel migration.
- Another recently completed study documented the location, size and mobility of large wood over a three-year period. This information helps in understanding the background loading of wood in the system and provides valuable context for designing and building flood repair or mitigation projects.
- A recent study of recreational use on the Cedar River provides insight into the location of entry and egress by recreational users as well as seasonality, timing, skill level, type and locations of recreational use. This information is considered in the design and construction of projects in the river and on its banks.

Flood risks in the Cedar River basin have also been managed through programs to coordinate with other agencies and to provide public outreach and education. These activities have been instrumental in helping local communities prepare for and respond to flooding:

- At a planning meeting each fall in advance of flood season, the region's first-responders meet to review operations, communications and weather predictions, as well as any special conditions to watch.
- Coordination with the City of Seattle has resulted in considerable and ongoing success in reducing flood magnitude, frequency and severity by careful monitoring and modification of operations at the Masonry Dam.

- Through partnerships with the community, King County can learn from residents' knowledge of the river while residents benefit from becoming involved and informed about actions King County might take that will affect the river. To this end, King County hosted a public meeting in the fall of 2011 to share information about upcoming projects with the community. This exchange of information is expected to become an ongoing program element.

Flood Hazard Management Identified Risks

The following are the flood hazard management risks identified for this river:

- Risks to public safety associated with localized flooding
- Risks to public infrastructure, including drainage systems, transportation routes, a municipal airport and a variety of other public service facilities
- Impacts on the regional economy related to flooding
- Risks to private structures, including homes, businesses and industrial properties
- Major landslide hazards from debris movement or flood backwater to homes near the many locations where the river abuts the steep valley wall.

Risks to those living, working, and traveling through flood-prone areas include damage to the structural integrity of homes, health hazards from contamination of water supplies or damaged septic systems, inundation of living spaces, and dangers associated with attempts to travel on flooded or damaged roads. The Cedar River also poses serious risk from erosion and channel migration, which can cause loss of property and in worst-case scenarios loss of residential structures.

Flood-prone areas of the middle and lower reaches of the Cedar River are dominated by residential uses. Many homes, and even entire neighborhoods, are located in the FEMA floodway or are surrounded by historical river channels, which indicates significant channel migration hazard. Historical protection methods, focused on armoring the bank to limit channel migration and erosion, have stabilized the bank in many locations but have done little to prevent the risks associated with overbank flooding. In some cases, these revetments have contributed to a false sense of security for new home buyers and encouraged development in flood-prone areas.

Additional flood risks result from naturally occurring landslides, which are common in this basin. The potential for nearly instantaneous deposition of large sediment volumes directly into the river channel poses a flood risk that cannot be eliminated by levees or revetments. A landslide may completely block the river, causing it to change course; may block a portion of the channel, causing it to flow over its banks; or may lead to sediment being transported and deposited in a downstream reach, where it may build up and reduce conveyance capacity over time. A landslide resulting from the 2001 Nisqually earthquake backed up the river and caused several homes upstream to be inundated by floodwater during a relatively low-flow condition. Had this landslide occurred during a high water event, it would have caused even greater damage.

The condition of the Cedar River's levees and revetments is also a concern. The older levees and revetments that line the river are frequently less robust than structures built using more current standards and biotechnical bank stabilization techniques. This appears to be particularly true along the Cedar River Trail, where highly variable materials were used to create revetments for an old railroad and were likely installed by simple end-dumping. Bank armoring structures can result in increased scour conditions immediately downstream, which may lead to decisions to extend the structures downstream.

Secondary effects of flooding include redistribution of sediment and large wood that is conveyed downstream in flood flows. Armoring of much of the river has limited the capacity of the floodplain to function as a source and sink for sediment and large wood, conveying more of these materials through the armored reaches.

Many of the levees and revetments are also a subject of concern with respect to the recovery of Endangered Species Act-listed species native to the Cedar River. The simple blankets of rock used to armor most of the Cedar River flood protection infrastructure do not foster development of a healthy riparian buffer or interaction between the river and its floodplain.

GREEN RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

The Lower Green and Duwamish River levees and revetments form a nearly continuous bank protection and flood containment system from the City of Auburn to the mouth of the Duwamish River. Little of the continuous Green River levee system meets current construction standards.

Lower Green River levees and revetments typically 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. Most of the historical levee reaches lack habitat features such as native riparian vegetation and instream wood accumulations. Howard Hanson Dam operations significantly reduce flood peaks but result in longer durations of elevated flows and relatively rapid rates of change in water levels. 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 have been observed. Such conditions can stress the levee and revetment system along the Lower Green River, with the potential to increase the occurrence and magnitude of slump failures. As a result, many of these flood management structures have needed frequent maintenance. Nearly all of them have been identified for needed rehabilitation and reconstruction to structural design standards better suited to the levels of flood risk present.

Levees and revetments along the Middle Green River are scattered, discontinuous and largely deteriorating. They are not intended to contain flood flows or prevent inundation, but rather to direct high flows and inhibit bank erosion and channel migration. Meanders upstream from the Hamakami Levee in 1990 destroyed both the upper end of the levee and its access roadway. In 2011, undercutting erosion and bank scour of the Lone’s Levee resulted from ongoing channel migration in the reach just upstream.

Major historical floods on the main stem Green River produced flows at Auburn of 24,000 cubic feet per second in 1933, which had a pre-dam recurrence interval of 19 years; 18,400 cubic feet per second in 1951, a 7-year pre-dam recurrence interval; and 28,100 cubic feet per second in 1959, a 39-year pre-dam recurrence interval. Typical flood damage included undermining by scour along the toe of levees and revetments in the Lower Green River and erosion of flood protection infrastructure or avulsion around it in the Middle Green River. Table 5-13 summarizes the most recent high flows on the Green River, as recorded at the Green River at Auburn gage.

TABLE 5-13.
HIGH FLOW RECORDS AT GREEN RIVER AT AUBURN GAGE

Date of Flood	Peak Flow (cfs)
January 18, 2011	10,400 cfs
December 2010	9,720 cfs
January 2009	11,100 cfs
November 2006	12,200 cfs
February 1996	12,400 cfs
November 1995	11,200 cfs
November 1990	11,500 cfs

Key Accomplishments Since the 2006 Flood Plan

Major Projects

The King County Flood Control District has carried out an annual program of flood hazard management activities since it supplanted the Green River Flood Control Zone District after completion of the 2006 Flood Plan. Significant among these was major reconstruction of flood-damaged containment levee segments that had been over-steepened and structurally unstable and were set back to achieve stable slopes. Additional easement widths were obtained in order to achieve these stable slope geometries at portions of the federally authorized Tukwila 205 Levee in the City of Tukwila; and at the Briscoe Levee, Narita-Kent Shops Levee, Myer's Golf Levee, and Nursing Home and Breda portions of the federally authorized Horseshoe Bend Levee in Kent.

In some locations, repairs were conducted at major levee and revetment segments where sufficient easements were not secured to provide for optimal setback reconstruction at stable slope angles, primarily due to high costs of acquisition of commercial property along the river. In these cases, slopes were largely repaired in situ with biostabilization measures and extensive toe and slope buttress installations. Such repairs were constructed recognizing that maintenance and repair costs may be higher over time. Examples of this category of major levee repair include a portion of the 42nd Avenue Revetment in the City of Tukwila and a portion of the Stoneway Lower Revetment along Frager Road on the left bank in Kent. Some federally assisted repairs were also completed in this manner as part of the Horseshoe Bend 205 Project in Kent and at the Galli's Levee and portions of the Dykstra Levee, both in Auburn.

Setback reconstruction of the Fenster Training Levee was accomplished with funding from the Washington State Salmon Recovery Fund Board to improve salmon habitat. This project was intended both in response to incremental deterioration of the older structure and to implement a priority habitat restoration project identified in the U.S. Army Corps of Engineers' Ecosystem Restoration Project and in the *Green River Salmon Recovery Plan*.

Other Projects

Two smaller repairs were completed at the Foster Golf Course at River Mile 9.95 in Tukwila, where erosion damage to the rock revetment was repaired with FEMA cost sharing. An additional slumping bank just upstream at the Foster Golf course was stabilized with plantings, and a log-and-piling structure was placed in the water column as mitigation for trees cut at other Green River levee slopes, to retain eligibility for U.S. Army Corps of Engineers flood damage repair funding. Smaller repairs also include

the installation of a flexible rubber check valve on the outlet culvert serving the private drainage system at the River Mobile Home Estates behind the Reddington Levee in Auburn.

Another significant project effort involves the local response to U.S. Army Corps of Engineers advice regarding levee vegetation. The U.S. Army Corps of Engineers uses levee vegetation as a major factor in the eligibility for federal assistance with post-flood levee repairs. In order to be eligible for such assistance, King County removed 461 trees from Green River levees in 2008 and 2009. State permits for this work require mitigation to replace the habitat functions of these trees, and land acquisition was necessary to provide this mitigation.

Land Purchases

In 2011, King County acquired the Teufel Nursery, a Lower Green River property that totals 36.7 acres and 0.92 miles of undeveloped shoreline along the Green River. This critical shoreline acquisition is in a portion of the Green-Duwamish River Watershed where open space, undeveloped shoreline, and functioning salmonid habitat features are scarce.

Emergency Preparation Due to Potential Dam Failure

A significant amount of unanticipated time, money and energy went toward preparing for the potential of a flood disaster due to seepage found at Howard Hanson Dam in 2009 after a significant flood event. Flood risk in the areas below the dam went from a 1-in-500 chance of exceeding design flows of flood control structures downstream to a 1-in-3 chance, creating the biggest challenge to flood control efforts in the Green River basin since the construction of the dam in 1962. Flooding scenarios were developed by the U.S. Army Corps of Engineers and local jurisdictions based on varying assumptions concerning containment at the dam. Following extensive review and discussion, with material support from the U.S. Army Corps of Engineers and funding assistance from the King County Flood Control District, the local jurisdictions of Tukwila, Kent, Auburn and King County embarked on an ambitious program to line 23 miles of the Lower Green River with sandbags and HESCO barriers. These temporary advanced measures were targeted to provide containment of flows up to a release of 15,300 cubic feet per second at Auburn without overtopping, representing roughly the estimated 500-year event as recalculated by the U.S. Army Corps of Engineers. Containment of higher levels of discharge was not considered feasible, though the threat of overtopping remained possible given the limited pool capacity at the dam.

Higher floods did not occur, and the U.S. Army Corps of Engineers confirmed a return to normal operations at the dam and reservoir in September 2011. The temporary advanced measures have been dismantled. The King County Flood Control District spent over $9.3 million installing, maintaining, and removing them. Combined disaster preparedness actions by local governments in response to damage to the dam was over $33 million.

FEMA Digital Flood Insurance Rate Map Updates

In 2006, King County initiated a major effort to re-calculate and map the floodplain of the Green River for submittal to FEMA. At the same time, FEMA began a program to convert all its existing Flood Insurance Rate Maps to a digital format, called Digital Flood Insurance Rate Maps. This nationwide effort started with an emphasis on heavily urbanized and populated floodplains, and the Green River was selected on this basis.

In compiling its existing Flood Insurance Rate Maps into a digital format, FEMA required that its standards for recognizing levee containment be confirmed for all levees formerly recognized as confining the 100-year flood. These standards require that a licensed professional engineer or federal agency such as the U.S. Army Corps of Engineers certify that the levee meets structural and performance criteria before it

can be accredited as providing a containment boundary in FEMA's mapping efforts. Along the Green River, the federally authorized Tukwila 205 levee system meets these standards, but no other Green River levee has been certified in this manner. As a result, FEMA extended modeled flood elevations beyond the levees and across much of the historical floodplain, and published preliminary Digital Flood Insurance Rate Maps in mid-2011 on this basis. Much as prior FEMA mapping overstated the levees' reliable protection, this FEMA mapping overstated the hazard in the levee-protected areas.

At nearly the same time, King County's flood mapping study was completed, with a much more refined model to support a far reduced overall footprint affecting much less of the valley floor. The resulting flood map was used as the basis for appeal of FEMA's preliminary Digital Flood Insurance Rate Map by King County and the cities of Renton, Tukwila, Kent, and Auburn. FEMA is now drafting new mapping procedures and standards in response to this appeal and to a nationwide reaction to the mapping approach used for the preliminary Digital Flood Insurance Rate Maps.

Local Initiatives and Partnerships

The heightened flood risk scenarios developed by the U.S. Army Corps of Engineers, seepage issues at Howard Hanson Dam, and FEMA's preliminary Digital Flood Insurance Rate Maps mapping of the Lower Green River have combined to significantly increase flood awareness in the Green River basin and has led to revisions in the Green River flood hazard management strategy. It has also led to a parallel effort by the City of Kent to certify and accredit all Green River levees in the city. This approach is supported by the King County Flood Control District as long as these efforts meet Flood District policies. Two exceptions have been made for the City of Kent's efforts to accredit the Boeing and Hawley Road levees, which are documented in a memorandum of understanding between the City and the District. These projects are funded through the Washington Department of Ecology, with the District as the project sponsor.

King County works with multiple federal, state, and local partners on flood risk reduction policies, plans and projects in the Green River watershed. Significant partnerships include the following:

- Partnership with the U.S. Army Corps of Engineers on a variety of topics, including levee maintenance of federally authorized levees on the Lower Green River, levee rehabilitation projects, ecosystem restoration projects, and levee vegetation management policies
- Regular meetings of the Green River Technical Committee made up of staff from Green River cities to provide recommendations to the King County Flood Control District on technical matters pertaining to the Green River basin
- Partnerships with the State of Washington granting and permitting agencies on specific Green River projects.

Flood Hazard Management Identified Risks

For the Duwamish and Lower Green rivers, ongoing instability of levees and revetments is the primary concern, and potential levee breach and inundation of most of the valley floor would result in extreme consequences. In the Middle Green River, discontinuous levees and revetments will continue to experience bank erosion due to lateral channel migration and channel avulsion.

Lower Green and Duwamish Levee Conditions

Constructed mainly in the mid-1970s, the basic levee system in place today consists of minimal toe buttress structures, over-steepened, sloughing banks, eroding channel margins, minimal or invasive vegetation, and significantly degraded habitat.

Middle Green River Channel Migration

Significant channel migration continues to occur in the Middle Green River. 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.

Possibility of Flows Exceeding Flood Infrastructure Design Capacity

Flood protection infrastructure on the Green River has been built and designed for a maximum flow of 12,000 cubic feet per second at the Auburn Gage for up to a 500-year flood event. The U.S. Army Corps of Engineers recently estimated that the current risk of a Howard Hanson Dam release exceeding 12,000 cubic feet per second at Auburn is 1 in 140, compared to the previously assumed 500-year risk. As shown in Table 5-14, this means that there is a 19-percent chance of flooding in the Lower Green River valley in 30 years rather than a 6-percent chance.

TABLE 5-14.
PROBABILITY OF EXCEEDING A DESIGN FLOW OVER VARIOUS TIMEFRAMES

	Probability of Exceedance			
Flood Recurrence	In 30 years	In 50 years	In 75 years	In 100 years
1:100 (100-year flood	26%	39%	53%	63%
1:140 (140-year flood[a])	19%	30%	42%	51%
1:200 (200-year flood)	14%	22%	31%	39%
1:300 (300-year flood)	10%	15%	22%	28%
1:500 (500-year flood)	6%	10%	14%	18%

a. This is the current U.S. Army Corps of Engineers dam design event

Value of Property, Buildings and Number of People Needing Flood Protection

The lower Green River is lined by a near continuous system of levees and revetments. The area is highly urbanized and has significant commercial, industrial, and high-density residential areas with accompanying high assessed values.

An analysis conducted by FEMA in 2009 showed that failure of the current levee system in a 100-year storm event would result in damage of $1.34 billion to $3.77 billion, including damage to commercial and residential buildings, building contents, and business interruption. Also in 2009, the U.S. Army Corps of Engineers produced a worst-case analysis of flooding below Howard Hanson Dam, the *2012 Green River Valley Dams Sector Exercise Series Secondary Impacts Economic Analysis*. This analysis assumed flows of 25,100 cubic feet per second at Auburn and a breach at the Tukwila 205 levee. The analysis found that direct and secondary impacts of interruption in economic activity in the short term of one to three years could be as much as $32 billion in output loss, with losses of 132,554 jobs and almost $8 billion in lost wages. The analysis concluded that long-term impacts on the economy would be felt through 2030. Subsequent work by the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers 2011) estimated that a large magnitude flood could result in over $3.7 billion in damages to structures, the loss of 72,000 jobs and $4.2 billion in wages, and over $16.7 billion in economic losses due to business disruptions in the first year alone.

Obligations and Costs of Environmental Protection; Move Toward Multi-Objective Approach to River Management

The Green River basin is home to thousands of residences and businesses and contributes to a large portion of the economy of the Seattle metropolitan area. The Green River is also important to the Puget Sound ecosystem, is home to listed salmon and bull trout species, and performs key ecological functions. As such, local governments are responsible for implementing salmon recovery targets for the Green River watershed, complying with the National Clean Water Act, and mitigating for negative environmental impacts, including those that result from flood control practices.

In an effort to manage the Green River in a way that will protect more people at less cost and address environmental and recreational needs, King County is exploring an approach to manage for multiple goals and objectives through a multi-objective river corridor approach. This holistic approach to watershed management has support from regional partners including the Muckleshoot Tribe and the Puget Sound Partnership. The concept is also gaining support from the U.S. Army Corps of Engineers and could be implemented through a System Wide Improvement Framework (SWIF), a process intended to reduce conflicts between the federal Endangered Species Act and compliance with the U.S. Army Corps of Engineers levee vegetation policies.

WHITE RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Flood Protection Structures

The primary White River flood protection infrastructure maintained by King County is the set of levees and revetments lining the channelized portion of the river from River Mile 10 to the King and Pierce county line near River Mile 5. These flood protection structures were built through the 1914 Inter-County River Improvement Agreement. They lock the White River channel in place from the Auburn Wall to the confluence with the Puyallup River. This system provides some flood containment, although the level of containment varies due to openings or low points in the bank armoring and because channel conveyance capacity downstream of A Street has been decreased due to ongoing sedimentation (Prych 1988; Herrera 2010; Czuba et al. 2010). None of the White River levees are federally certified or enrolled in the U.S. Army Corps of Engineers Public Law 84-99 program.

There are no County flood structures from River Mile 10 through the Muckleshoot Indian Reservation and up to the State Route 410 bridge near Enumclaw. This portion of the White River functions naturally, without influence from floodplain modifications or land development. There are no County revetments or levees between State Route 410 and Mud Mountain Dam. The lower mile of the Greenwater River has two revetments on the right bank that provide bank erosion protection for a row of residential properties.

Privately owned structures such as the White River Hatchery and Cascade Water Alliance diversion dam are periodically affected by flood flows and sediments.

Flood History

In the 1990s and early 2000s, the combination of a channelized system along both riverbanks and the flood control operations at Mud Mountain Dam resulted in less frequent and less significant overbank flows than occurred historically along the lower reaches of the White River. Flood damage along lower reaches of the White River in this timeframe typically was in the form of bank erosion and undermining of existing bank armoring. However, present channel capacity in the river reach between A Street and 8th

Street is such that flood flows overtop into uninhabited areas at about 3,600 cubic feet per second and into inhabited areas at flows of about 8,000 cubic feet per second. Two recent large flood events resulted in significant damage to developed areas, as described below.

November 2006 Flood Event

In November 2006, river flows overtopped low-level banks in the Pacific area, mainly entering riverside wetlands and Pacific City Park ball fields. Some roadways, such as 3rd Avenue in Pacific, also received shallow flooding and were temporarily closed. Damage from this flood event was not significant and consisted mainly of minor scour of near-bank areas, deposition of silts and sands in the park areas, and some localized flood debris that necessitated landscape-level clean-up.

Above Mud Mountain Dam, flooding and bank erosion in November 2006 resulted in the temporary closure of State Route 410 within Federation Forest State Park, south of Greenwater. The temporary closure cut off access to the community of Greenwater and other communities, as well as access to the Crystal Mountain Ski Resort located to the south in Pierce County.

January 2009 Flood Event

The flood of January 2009 had a controlled flow release from Mud Mountain Dam similar to that which occurred in November 2006; both events had a peak released flow of about 11,700 cubic feet per second. However, flood damage in 2009 along the Lower White River was significantly different.

In 2009, floodwaters overtopped the right bank by Pacific City Park in the late hours of January 8 and flowed southward through the White River Estates neighborhood, continuing into Pierce County along the floodplain areas of Butte Avenue. Over 100 homes in White River Estates neighborhood, several commercial businesses along Butte Avenue, and the Megan's Court Apartments near Pacific City Park experienced flooding of first floor living spaces, office areas, and building crawl spaces. Evacuations of residents occurred along Butte Avenue, south of White River Estates, and many efforts were made by citizens and City of Pacific staff to place sandbags in an attempt to protect residential structures.

On the morning of January 9, the U.S. Army Corps of Engineers ordered a reduced flow release from Mud Mountain Dam of 9,000 cubic feet per second. Given the large storm and the accumulated volume of stored floodwaters in the reservoir, the White River continued to experience high flows for several days as floodwaters were released from the dam. Attempts to pump crawl spaces were ineffective due to high groundwater and river conditions. Surface water was not draining in many locations because several stormwater outfalls did not have flap gates or back flow valves, exacerbating flooding.

As flows continued to recede, the U.S. Army Corps of Engineers responded to the City of Pacific's request to place a temporary dirt berm along the revetment edge of Pacific City Park to preclude overtopping in any subsequent flood event for the 2009 flood season. The berm was intended to prevent the overbank flow path that carried floodwaters toward the north side of the White River Estates neighborhood.

On the opposite riverbank, floodwaters overtopped into agricultural lands in the City of Sumner and overtopped 8th Street, also known as Stewart Avenue. This main arterial was closed during the night of January 9 and for most of the next day. As river flows decreased, private landowners also built dirt berms along the edge of the wetland where overtopping occurred on January 8-9.

Upriver areas and flood protection infrastructure within the City of Auburn were not damaged during the January 2009 event, although some concern was raised regarding scour and debris accumulation near the right bank abutment of the A Street bridge.

A small residential area along the White River almost a mile downstream from the confluence of the Greenwater River experienced severe overbank flows between homes and State Route 410, cutting off access. A significant amount of flood debris—wood and sediment—was carried across these properties, and the riverbank eroded closer to the homes. These flood-damaged private homes were repaired and remain close to the active channel, where they are exposed to flood and channel erosion hazards.

Streamflow Gages

Table 5-15 summarizes the most recent high flows on the White River, as recorded at the White River at Buckley gage.

TABLE 5-15.
HIGH FLOW RECORDS AT WHITE RIVER ABOVE BOISE CREEK AT BUCKLEY (USGS GAGE 12099200) AND WHITE RIVER ABOVE BOISE CREEK AT BUCKLEY (USGS GAGE 12099200)

Date of flood	Peak Flow (cfs)	Gage
January 2009	11,800 cfs	12099200
November , 2006	14,700 cfs	12099200
December 1995	13,900 cfs	12100000
January 1990	13,300 cfs	12100000
November 1986	14,900 cfs	12100000
December 1977	14,300 cfs	12100000

Ongoing channel aggradation has resulted in decreased channel conveyance capacity in some lower reaches of the White River, especially between A Street and 8th Street (Herrera 2010; Czuba et al. 2010). During the January 2009 flood event, it became apparent that aggradation was affecting the accuracy of the flow discharge readings at the gage at A Street, USGS gage 12100496, White River near Auburn. Consequently, the U.S. Geological Survey installed USGS gage 12100490, White River at R Street near Auburn, a location where the channel is not affected by ongoing sedimentation. USGS gage 12100496 still functions at A Street to provide stage-only readings.

With continued concerns about the effect of ongoing sedimentation on flow levels in this area, King County has requested that the U.S. Geological Survey install additional stage-only gages on the lower segment of the White River between the R Street and 8th Street bridges. Three new stage-only gages are being installed, and the existing A Street gage is being replaced, with stage sensors that use radar to read water levels. This will avoid the potential fouling of equipment by sediment or debris. Once calibrated to flow discharge readings at R Street, this coordinated set of stage gages will provide real-time information on fluctuations in stage levels as a more detailed method to monitor the potential effect of sediment levels on floodwater elevations.

Key Accomplishments Since the 2006 Flood Plan

Structural Projects and Acquisitions

In November 2006, the Stuck River Drive revetment was damaged over a length of 300 feet. In the summer of 2008, the revetment was repaired with large wood and rock placed along the toe of the bank. Biostabilization techniques were used to reconstruct the mid-bank. The repair is being monitored annually and was undamaged during the January 2009 flood event. The revetment protects Stuck River Drive, utilities and the City of Auburn paved trail.

In the fall of 2009, the U.S. Army Corps of Engineers provided materials to King County for installation to provide temporary flood protection in the City of Pacific, which experienced significant flooding in the January 2009 flood. King County crews installed over 4,000 lineal feet of temporary flood protection riverward of 3rd Avenue S.E., the Megan's Court Apartments, and the White River Estates neighborhood. A combination of HESCO barriers and large sand bags provide an increased level of flood protection for these flood-prone areas until a permanent flood risk reduction structure can be designed and constructed. To further reduce flood risks to White River Estates, the City of Pacific coordinated an effort to build a sandbag berm along the southern edge of the neighborhood to protect against low-velocity backwater flooding from the White River and Boeing Ditch. The U.S. Army Corps of Engineers and Pierce County Surface Water Division aided in the construction of the berm. Altogether, the temporary flood structures in the City of Pacific may also reduce flood risks to residences and industrial properties along Butte Avenue.

Also in 2009, King County was approached by and began discussions with property owners regarding acquisition of land for a setback levee in the City of Pacific. During 2010 and 2011, 11 homes in the White River Estates and nearly 7 acres of undeveloped agricultural land were acquired from willing sellers. Five homes, several out-buildings and landscape materials were relocated through an auction. The remaining six homes were demolished by a private contractor. The properties were converted to open space in the White River right bank floodplain. Grant funding from the Conservation Futures Trust and the King County Parks Levy contributed to the agricultural acquisition.

Since 2008, King County has been developing a project design for the County Line Levee Setback Project on the left bank of the White River from the 8th Street bridge to the A Street bridge. The project includes construction of over a mile of new setback levee and biorevetment, along with removal of existing channel-constricting flood structures. To date, accomplishments include design development, land acquisition and funding partnership agreements. Permit-ready designs, State Environmental Policy Act submittals and permit applications will be completed by the end of 2012. Three parcels have been acquired, and negotiations with five other landowners are continuing. Funding partners include significant support from the Natural Resource Damage Assessment Partners, Pierce County Surface Water Division and the Salmon Recovery Funding Board. Final design and permit approvals are expected by the end of 2013, with a construction start date of May 2014.

Technical studies

Significant King County technical studies completed for the White River since 2006 include the following:

- The 2009 update of flood hazard mapping for the Pacific-Auburn area and the river segment from State Route 410 to Mud Mountain Dam (Northwest Hydraulic Consultants 2009)
- A sediment-trend analysis commissioned by King County to characterize existing sediment conditions and provide insight on future in-channel sediment conditions for the reach from the Muckleshoot Indian Tribe Reservation to the 8th Street bridge (Herrera 2010)
- Two White River sediment investigations in partnership with Pierce County and the U.S. Geological Survey:
  - A study that demonstrated decreased channel conveyance capacity and evaluated potential sediment management remedies such as gravel removal and levee setbacks (Czuba at al. 2010)
  - A study that assessed sediment inputs, transport and deposition in the river systems draining Mount Rainier (Czuba et al. 2012)

- A U.S. Geological Survey investigation now underway and supported by King County to examine the impact of flood management actions such as levee setbacks on the biological health of juvenile salmon (Black 2012 in progress).

These studies are valuable for understanding the White River system, particularly as design progresses to implement reach-length levee setback projects that seek to reduce flood risks while restoring the process, structure and function of the natural river system. The ability to complete these technical studies depends on the timely collection of topographic data, including the periodic resurvey of river cross sections and the collection of LiDAR data sets and aerial imagery. Topographic data in and adjacent to the White River channel are collected as part of King County's ongoing channel monitoring program, which resulted in compilation of channel data collected since the 1970s and ongoing collection of new data in the channel from River Mile 4.4 to River Mile 10.6. King County also coordinates with the City of Auburn in the city's resurvey of channel cross sections from A Street to R Street in most years since 1996; the Auburn data have been included in the County's ongoing channel monitoring program. King County has also conducted sampling and analysis of in-channel sediments.

The TransCanada Levee Setback Feasibility Study, completed in 2011, identified a preferred alternative for restoring process and function within a channelized lower section of the White River while preventing an increase in flood hazard from inundation or channel migration outside the study area. Channel constriction and adverse flow velocities currently limit salmonid habitat and natural riverine processes. The study was funded by the Washington State Salmon Recovery Funding Board and was coordinated with the Muckleshoot Indian Tribe, a project partner.

Flood Hazard Management Identified Risks

Flood hazards and flood risks vary from segment to segment in the White River flood hazard management corridor. Each segment has varying levels of risk conditions, reflective of its distinct physical hazards and the floodplain development and land uses that they impact. Resolving and lowering these risks requires different strategies, with incremental objectives implemented in the near-term and over several years.

8th Street to River Mile 10 Segment

Channel gradient decreases dramatically in this segment as the river flows down the White River alluvial fan, making it a natural depositional area. The channel is highly modified, constricted and disconnected from its floodplain, and ongoing sedimentation decreases the flood conveyance capacity. This is most apparent in the reach between the 8th Street and A Street bridges, where concrete revetments, a short length of levee, and bridges at both ends constrict the channel. Here, gravel bars have lengthened and increased in overall volume of material, and local scour resulting from the shifting channel has undermined some of the revetment.

Houses along 3rd Place South in a residential subdivision at the top of this reach are near the top of the revetment. Over time, the freeboard has decreased, placing these residences at high risk of flooding. Loss of channel conveyance presents a growing potential for overbank flooding to these right-bank riverside homes and for further damage to the aging and degraded concrete revetment along the right bank. The temporary flood structure installed by King County in 2009 reduces but does not eliminate the risk of overbank flooding reaching homes further south, including the White River Estates community.

Loss of channel conveyance also has resulted in river flows overtopping the left bank into a large wetland area. Private landowners have constructed dirt berms along the edge of the wetland to prohibit overbank flows from entering their agricultural and commercial properties, but modeling indicates an increased likelihood of major flooding in these areas and inundation of 8th Street, as occurred in January 2009.

Revetments and fill in the floodplain and channel between the A Street and R Street bridges also reduce flood conveyance capacity. With the valley wall protruding from the south side along Oravetz Drive just downstream of the R Street bridge, flood flows impinge into the north bank, where Mt. Baker Middle School is located. As flows turn from this meander bend, they are directed downstream into the unprotected left bank, eroding the bank and threatening trails in Roegner Park. These erosive flows could also affect the Auburn Riverside High School property, which is partly on fill that was placed in an historically highly mobile part of the active channel and floodplain. Opportunities to reconnect the river with its floodplain are more limited in this reach, and warrant further investigation.

Upstream from the Game Farm Wilderness Park on the Muckleshoot Indian Tribe Reservation, the channel is actively migrating and floodwaters have breached through the TransCanada levee, which extends from the Wilderness Park levee at River Mile 8 to the Williams natural gas pipeline crossing at River Mile 10.5. Flooding in the 1990s included overbank flows entering the floodplain from several breached locations and traveling across public and private land parcels before combining into a single, large floodplain channel that reentered the river by breaching through the back side of the Wilderness Park levee. A trail embankment with small culverts was installed by the City of Auburn after 1996 to receive these flood flows and prevent future damage to the trail crossing within the park. However, based upon the sediment trends analysis (Herrera 2010) and ongoing channel monitoring data, the main channel elevation of this river reach has degraded, generally since the 1970s and locally since the 1990s. The recent flood study (Northwest Hydraulic Consultants 2009) indicates that overbank flows would not occur during the 100-year event, which is consistent with channel degradation and increased conveyance capacity in this reach. Although overbank flooding is less likely, lateral channel migration is expected to continue where a meander bend is eroding into the left bank floodplain due to high velocities and direct impingement of flows on the already breached levee site at River Mile 9.5. The only structure that is at risk from channel migration for the foreseeable future is the breached TransCanada levee itself.

River Mile 10 to State Route 410

The segment from River Mile 10 to the State Route 410 bridge at about River Mile 22 is a natural and dynamic portion of the White River through the White River Canyon. Typified by little floodplain development or channel modification, there are no known significant flood risks. Channel migration recruits wood and sediment, which is delivered downstream to more constricted reaches.

State Route 410 to Mud Mountain Dam Segment

The segment from the State Route 410 bridge to Mud Mountain Dam at River Mile 29.7 has limited land development. However, a small residential community at River Mile 26.5 along Red Creek, just downstream of Mud Mountain Dam, is at high risk because of the potential for rapid channel changes, which could threaten residents as well as any rescuers who may respond in an emergency evacuation. No specific structural damage was reported in this community from the 2006 or 2009 flood events, although bank erosion was evident.

Mud Mountain Dam to Greenwater River Segment

The uppermost White River segment within King County's hazard management corridor, from Mud Mountain Dam to the confluence of the Greenwater River at River Mile 45.8, is unregulated and can experience significant, uncontrolled floods. The channel here is encroached upon by State Route 410.

Residential properties on the right bank between Federation Forest State Park at River Mile 45 and at the confluence with the Greenwater River experience periodic flooding and are at risk of channel migration hazards. A residential property on the right bank at the confluence of the White and Greenwater rivers experienced significant flooding in the 1995 and 1996 events due to rapid channel movement and

overbank inundation. This area, along with State Route 410, could also be flooded by water forced out of the Greenwater River channel as a result of the accumulation of logs and debris on the center pier of the State Route 410 bridge.

Greenwater River Segment

A residential community within the first river mile of the Greenwater River includes numerous summer cabins and many year-round residences near the riverbank. Inundation of overbank areas has impacted the homes in this area.

CHAPTER 6.
PLAN IMPLEMENTATION

Chapter 6 of the 2006 Flood Plan describes Plan implementation considerations and provides recommendations associated with King County's implementation role, partnership and coordination opportunities, and adaptive management strategies. Only very minor updates were made to Chapter 6, as described below.

IMPLEMENTATION OF THE 2006 FLOOD PLAN

Under the guidance of King County Flood Control District leadership and in partnership with King County jurisdictions, King County's Water and Land Resources Division provided the staff resources and the technical expertise to implement the recommendations in the 2006 Flood Plan. In the time since the adoption of the 2006 Flood Plan, several of the high-priority project and program actions outlined in the 6-Year Action Plan have been implemented. In addition, many other projects and programs were implemented that were not identified in the 2006 Flood Plan but emerged from newly identified risks or other shifts in priorities. Plan implementation has thus far generated significant public benefit, including the reduction of flood and channel migration risks, the protection of roads and other critical infrastructure that support regional safety and economic viability, the enhancement of salmon habitat, and open space protection within floodplains.

CLIMATE CHANGE AND MAJOR RIVER FLOODING

Current climate change models predict a range of possible future timing, frequency, and volume of precipitation in Western Washington along with increased temperatures. There is currently a deep level of uncertainty about which outcomes are most probable, but there is some likelihood that precipitation will increase, that more precipitation will fall as rain instead of snow, and that the magnitude, duration, and frequency of extreme precipitation events will grow. As a result, fall and winter flood events along King County's major rivers may be more frequent and last longer. Climate change is also expected to affect atmospheric rivers—narrow corridors in the atmosphere responsible for most of the horizontal transport of water vapor outside the tropics that can produce extreme amounts of rainfall in the Pacific Northwest. More frequent flooding events and more erosive flows may test the protective capacity of King County's aging system of 500 levees and revetments. The potential for increased magnitude and frequency of fall and winter flood events in King County and the deep uncertainty about which effects the County will actually experience add urgency to the work already identified in the 2013 Flood Plan Update. The implications of climate change for flooding in King County require immediate near- and long-term strategies to increase the resilience of both natural systems and flood facilities to function under a range of outcomes.

King County is analyzing climate change models and trends to determine possible effects on King County's weather and flooding patterns. Recent work (King County 2010a) found a general trend toward higher discharges and precipitation in November and lower discharge and precipitation during summer, consistent with University of Washington modeling on how climate change may affect Pacific Northwest rivers. New coastal flood standards for King County adopted in 2011 took into account expected sea level rise from climate change to provide increased resilience to future flooding. These standards comport with an estimated sea level rise of 2 feet (based on a January 2008 report from the University of Washington Climate Impacts Group; Mote et al. 2008).

While the scientific understanding of and ability to model climate change outcomes specific to flooding is highly imperfect, King County will continue to study the relationships between climate change and flooding and will monitor emerging climate change findings and models for more robust predictions into

the future. The 2013 Flood Plan Update proposes proactive public safety actions consistent with the University of Washington Climate Impact Group's recommendations to minimize the potential effects of a warming climate on major river flooding in King County (Snover et al. 2007). The 2013 Flood Plan Update also includes actions and planning strategies, such as setting back levees and using a regional river corridor approach, that increase the resilience of natural systems under a range of uncertain climate change outcomes.

CHAPTER 7.
FUNDING

King County faces significant challenges in the years ahead to deal with a deteriorating flood protection infrastructure, most which was built over five decades ago. Many flood protection structures are currently damaged, are not regularly or adequately maintained because of funding limitations, and are subject to major damage or failure during a major flood event. Failure of these structures could have dramatic and adverse impacts on people's lives and property. The economic viability of the region could also be dramatically affected. Adverse impacts from floods also extend to roads, bridges and other public and private infrastructure and include significant impacts on important natural and environmental resources. Maintaining and reconstructing King County's flood risk reduction infrastructure to present-day standards is vitally important for public safety and for the economic well-being of King County. A strategic financial investment plan is essential to the future implementation of capital improvements, maintenance and repair of existing flood protection infrastructure, acquisition, relocation and elevation of at-risk structures, and flood hazard mapping studies. In addition, flood hazard warning and education are essential to protecting significant public and private investments throughout King County.

With the formation of the King County Flood Control District and establishment of a countywide levy to fund the District's activities, King County is better able to provide regional, comprehensive flood hazard management services that help protect public safety in the event of a flood disaster. District resources are enhanced with grant funds from local, state and federal agencies, as well as a small contribution from the Inter-County River Improvement Fund. Table 7-1 provides an accounting of revenues and expenditures for flood programs in King County for 2006 through 2011.

This chapter describes funding sources and accomplishments, partnerships, tax levy suppression and levy increase limitations, projected expenditures and revenue, and options to address projected gaps between expenditures and revenues.

LOCAL FUNDING DEDICATED TO FLOOD RISK REDUCTION

King County Flood Control District

One of the most significant recommendations implemented from the 2006 Flood Plan was the creation of the King County Flood Control District in 2007 and the establishment of a levy to fund the District's activities in 2008. The King County Flood Control District is the main dedicated source of funding for the programs and projects in the 2013 Flood Plan Update. Since the first revenue collection under the Flood District levy, annual revenue collected has increased from to $33.2 million in 2008 to $36.5 million projected for 2012, an average annual increase of 0.8 percent. The Flood District levy rate was 10 cents per $1,000 assessed value when the District was established and has increased to 11.6 cents per $1,000 assessed value in 2012. As the total revenue has increased by 0.8 percent per year, the main reason the tax rate has increased is the decline in assessed values across King County during this timeframe.

River Improvement Fund

Prior to the establishment of the King County Flood Control District, the main source of local funding for flood risk reduction was the River Improvement Fund. Authorized under Chapter 86.12 RCW, the River Improvement Fund was a countywide property tax levy, including properties in incorporated cities, assessed at an equal levy rate and based on a property's total taxable assessed valuation. The River Improvement Fund was eliminated by the King County Council in 2008, removing approximately $3 million of revenue per year. Some revenue was collected from delinquent taxes after 2008, and the fund was closed in 2011.

TABLE 7-1.
FLOOD PROGRAM HISTORICAL COSTS AND REVENUES

	2006	2007	2008	2009	2010	2011
Revenue						
King County Flood District Levy	—	—	$33,239,735	$34,748,473	$35,555,142	$35,962,280
Green River Flood Control Zone District Levy[a]	$977,276	$2,171,229	$209,483	$18,598	$0	—
River Improvement Fund Levy[b]	$2,649,581	$2,733,974	$566,636	$44,900	$461	$1,000
Interest Earnings	$93,138	$81,798	$531,088	$469,154	$303,461	$258,965
Inter-County River Improvement	$51,257	$50,225	$67,000	$60,943	$46,108	$45,359
Grants	$967,381	$765,759	$1,862,116	$1,754,006	$3,515,863	$2,514,314
City Reimbursements[c]					$667,650	
Miscellaneous Revenue	$150,586	$301,203	$304,023	$235,304	$399,096	$193,257
Total Revenue	**$4,889,218**	**$6,104,189**	**$36,780,082**	**$37,331,379**	**$40,487,780**	**$38,975,176**
Expenditure						
King County Flood District Administration	—	—	($213,732)	($743,552)	($417,847)	($645,160)
Levy Suppression Payments[d]	—	—	—	—	—	($3,090,823)
Flood Operating	($3,907,053)	($5,637,392)	($4,517,110)	($5,399,826)	($5,914,061)	($5,969,528)
Flood Capital	($1,669,593)	($1,300,402)	($13,084,183)	($19,034,655)	($26,523,921)	($19,580,206)
Total Expenditure	**($5,576,646)**	**($6,937,795)**	**($17,815,025)**	**($25,178,034)**	**($32,855,828)**	**($29,285,716)**

a. The Green River Flood Control Zone District and levy were subsumed by the creation of the King County Flood Control District.
b. In 2008 the contribution from the River Improvement Fund was removed from the flood program, leaving only receipts of delinquent collections.
c. The 2010 city reimbursements were payments from the City of Auburn for King County's flood preparation work on the Porter Bridge and Valentine levees.
d. Payments made to senior taxing districts to voluntarily restrict their tax levy in order to avoid suppression of the entire Flood District levy.

Inter-County River Improvement Fund

Under Washington State law, whenever a river forms the boundary or part of the boundary between two counties or where the river waters alternate between counties with potential for flood damage in both counties, the counties may enter into an interlocal agreement to cooperatively develop and fund flood control improvements and maintenance (Chapter 86.13 RCW). King and Pierce counties created the Inter-County River Improvement Fund under this law in 1914 for the purpose of jointly funding maintenance and repair of flood protection infrastructure along the White and Puyallup Rivers. The Inter-County River Improvement Fund is a countywide property tax levy within King County assessed at an equal levy rate and based on a property's total taxable assessed valuation. From 1991 through 2011, the Inter-County River Improvement Fund tax levy has remained constant, collecting approximately $50,000 per year. The agreement establishing the Inter-County River Improvement Fund expires in 2020.

Like the River Improvement Fund, the Inter-County River Improvement levy is a component of King County's general levy and subject to statutory levy limits. Any levy increases beyond 1 percent in the Inter-County River Improvement levy must be offset by equivalent reductions in funding for other services funded by King County's general levy unless a majority vote of King County voters approves an increase that exceeds statutory levy limits.

IMPACT OF STATUTORY LEVY RESTRICTIONS

Impacts of Levy Increase Limitations

Prior to 1997, taxing districts were limited to an annual property tax levy increase of 6 percent over the prior year's levy plus an allowance for new construction values. Under Washington State Referendum 47, passed by voters in 1997, the annual increase in levy revenue remained limited to 6 percent; however, to enact an increase greater than the general inflation rate required a super-majority vote by the taxing district's governing body. Many jurisdictions, including King County, responded to this initiative by limiting the annual growth in property taxes to the general rate of inflation.

In 2001, Washington State voters approved Initiative 747, which changed the 6-percent limit to 1 percent. The state law, which went into effect in 2002, limits annual levy revenue increases to 1 percent, unless a majority of voters approve a larger increase. This limitation affects King County's ability to fund flood hazard management projects and programs because the property tax levies for the King County Flood Control District Fund and Inter-County River Improvement Fund do not provide financial surety for revenue to keep pace with inflation. As the assessed valuation of properties in King County has historically appreciated at a rate greater than the 1-percent levy rate increase limit set by Initiative 747, the levy rate and total levy revenue decrease relative to existing property values.

Since 2007, the average annual levy increase for the District has been 0.8 percent. The levy increase includes new construction, which is not subject to the levy rate limit established under Initiative 747. Although Flood District levy increases have been relatively consistent with the rate of inflation over this time period, the resultant level of funding is inadequate to address total flood risk reduction needs. In years when inflation is less than 1 percent, the levy rate can be increased up to 1 percent if emergency conditions arise, such as the increased flood risk resulting from the reduced capacity of the Howard Hanson Dam.

Impacts of Levy Rate Suppression

Article 7, Section 2 of the Washington Constitution limits the annual increase in the property tax rate that may be imposed on an individual parcel of property without voter approval to 1 percent of its true and fair value. Taxes imposed under the 1-percent limit are called regular levies. They are further restricted by statute as follows:

- The state portion of the property tax levy is limited to $3.60 per $1,000 of assessed value.
- The County portion of the property tax levy is limited to $1.80 per $1,000 of assessed value.
- The portion of the property tax levy for cities and towns is limited to $3.375 per $1,000 of assessed value.
- The combined levies by cities, counties and junior taxing districts are limited to $5.90 per $1,000 of assessed value. If the combined rates of these districts exceed $5.90, the rates of these taxing districts are reduced according to statutorily set priorities until the combined rate is within the $5.90 limit.

Table 7-2 shows the priorities established by statute for taxing authorities included in the $5.90 limit on total local levies. Flood Control Districts are among the lowest priority taxing authorities—sixth out of seven categories. State statutes require that the lowest-priority taxing district have its tax levy reduced pro rata or eliminated until the total levy limit is no longer exceeded.

TABLE 7-2.
ORDER OF PRIORITY WITHIN THE $5.90 LIMIT FOR PROPERTY TAX

Priority Ranking	Local Taxing Authority	
First	County—includes River Improvement Fund and Inter-County River Improvement Fund County Road City	***Highest Priority***
Second	Fire (1st 50¢) Regional Fire Protection Service Authority (1st 50¢) Library Metropolitan Park created before 1/1/2002 (1st 50¢) Public Hospital (1st 50¢)	
Third	Fire (2nd/3rd 50¢) Regional Fire Protection Service Authority (2nd/3rd 50¢)	
Fourth	Metropolitan Park created after 1/1/2002	
Fifth	Public Hospital (25¢) Unprotected Metropolitan Park (25¢) Cemetery (11.25¢) All other junior districts except those in 4th & 5th priorities	
Sixth	Flood Control Zone Districts	
Seventh	Park & Recreation Service Area Park & Recreation Cultural Arts, Stadium City Transportation Authority (Monorail)	***Lowest Priority***

The issue of levy suppression, although more commonly occurring in rural counties throughout Washington State, faced King County for the first time in recent history in 2010. Levy suppression occurs when the local taxing district rates in any area of the county exceed the limit of $5.90 per $1,000 of assessed value. There are over 400 local taxing areas, which are commonly referred to as "levy codes." Each code contains some combination of the various taxing districts that levy taxes throughout the county. Several local tax measures are excluded from this $5.90 cap, including the Ferry District, the Emergency Medical Services Levy and the Conservation Futures Tax Levy.

If any levy code exceeds the $5.90 limit, there can be implications for taxes and services throughout the county. Under the 2010 property tax rates, one levy code was projected to be as much as 39 cents over the $5.90 per parcel cap, which would result in pro-rationing of property tax levies within that code. Pro-rationing would lead to complete elimination of the King County Flood Control District junior tax levy. This pro-rationing would occur because the District is the most junior district in the area under state law, so it is suppressed first. Because the Flood District levy applies countywide, it must be levied uniformly across the entire county. Therefore, if the tax is suppressed in any area of the county, it must be suppressed across the entire county.

State law allows junior taxing districts to avoid suppression by transferring funds to other more senior taxing districts to reduce their tax rate so that the $5.90 cap is not exceeded and suppression is avoided (RCW 39.67.020). The Flood District entered into agreements with multiple more senior taxing districts in 2010 to avoid suppression of the District's $36 million levy, at a cost of $3.09 million. As a result of a legislative change in 2011, the District is protected from future suppression until January 1, 2018.

GRANT AND PARTNERSHIP FUNDING

The significant increase in local funding provided by the King County Flood Control District property tax helps to leverage external fund sources. Prior to the formation of the District, external grant funds were approximately $1.5 million to $3.5 million per year. This money was largely provided by FEMA disaster mitigation grants and public assistance, with cost-share percentages ranging from 75 to 97.5 percent, depending on the grant program.

For 2006-2012 over $27 million in grant funding was awarded from FEMA, the Washington Department of Ecology Flood Control Assistance Account, and the Washington Salmon Recovery Funding Board. Another $25 million was provided in 2008-2009 by the U.S. Army Corps of Engineers for cost-shared flood damage repair projects. When costs such as rights-of-way, permits and mitigation are factored in, the cost share for this program ranges from 35 to 75 percent federal funding. Table 7-3 summarizes grant revenue received or secured from 2008 through 2011.

TABLE 7-3.
GRANT REVENUES RECEIVED IN PURSUIT OF THE KING COUNTY FLOOD DISTRICT WORK PROGRAM

Type	2008	2009	2010	2011	**Total**
Conservation Futures Tax Levy			$150,000		**$150,000**
Federal Salmon Recovery Grants	$1,738,833	$171,719	$7,843	$373,393	**$2,291,788**
Federal Emergency Management Agency	$123,283	$736,576	$2,904,341	$1,811,824	**$5,576,025**
King Conservation District	$0	$400,000			**$400,000**
Puget Sound Acquisition & Restoration	$0	$432,150	$341,678	($216,358)	**$557,471**
Total	**$1,862,116**	**$1,740,445**	**$3,403,863**	**$1,968,860**	**$8,975,283**

NOTE: This table includes revenue received by the King County on behalf of the King County Flood Control District. It does not include approximately $25 million in Army Corps of Engineers levee repair cost-share funding during 2008-9.

HISTORICAL PROJECT AND PROGRAM EXPENDITURES

King County has made significant progress on the implementation of flood risk reduction projects since release of the 2006 Flood Plan. Capital projects and technical studies totaling over $104 million have been completed. A total of $42 million was leveraged through grant partnerships between 2008 and 2011. $25 million of this amount was provided as a cost-share by the Army Corps of Engineers for levee repairs in 2008-9. Operating expenditures for the ongoing floodplain management activities described in Chapter 5 have ranged from $5 million to $7 million since the District was established in 2008. Capital expenditures to date in each basin are shown in Table 7-4. Basin-specific accomplishments are described in Chapter 5.

TABLE 7-4.
CAPITAL EXPENDITURES BY BASIN AND PROJECT PHASE 2006-2012

	Snoqualmie	Cedar	Green	White	Countywide Misc.	Seattle	Sub-Regional Opportunity Fund	**Total**
Acquisition	$18,662,000	$12,714,000	$12,315,000	$4,856,000	—	—	—	**$48,547,000**
Levee Construction/ Repair	$2,301,000	$3,572,000	$7,082,000	$484,000	—	—	—	**$13,439,000**
Design	$3,446,000	$3,121,000	$3,877,000	$2,758,000	—	—	—	**$13,202,000**
Elevation	$2,735,000	—	—	—	—	—	—	**$2,735,000**
Emergency Repair/Prep	$24,000	$120,000	$6,489,000	$358,000	—	—	—	**$6,991,000**
Feasibility	$416,000	—	$780,000	—	—	—	—	**$1,196,000**
Farm/Flood Task Force	$283,000	—	—	—	—	—	—	**$283,000**
Environmental Mitigation			$35,000		—	—	—	**$35,000**
Capital Monitoring/ Maintenance	—	—	—	—	$539,000	—	—	**$539,000**
Payments to Other Jurisdictions	—	—	—	—	$33,000	$7,264,000	$9,549,000	**$16,846,000**
Miscellaneous	—	—	—	—	$715,000	—	—	**$715,000**
Total	**$27,867,000**	**$19,527,000**	**$30,578,000**	**$8,456,000**	**$1,287,000**	**$7,264,000**	**$9,549,000**	**$104,528,000**

PLAN IMPLEMENTATION AND ACTION PLAN FUNDING

The formation of the King County Flood Control District and the creation of a new countywide property tax have significantly increased regional resources available for flood risk reduction actions. However, the loss of the River Improvement Fund and the addition of several new expenditures raise questions about whether to extend the timeframe for implementing flood-related programs and projects or find other revenue to offset unanticipated expenditures so that projects can be completed more quickly. In 2007, the recommended financial plan for the District included $428 million in revenues and $427 million in expenditures. Since then, several decisions and on-the-ground changes have greatly increased expenditures while simultaneously reducing projected revenue:

- River Improvement Fund revenue of $3 million per year was removed.
- The Sub-Regional Opportunity Fund was established, increasing expenditures by $3.6 million per year.
- The Seattle Seawall was amended to the 2006 flood Plan in 2011, at a cost of $30 million.
- Flood damage and temporary flood response expenditures of $17 million were incurred.
- Green River sandbag removal costs of $5.8 million were incurred.
- Cooperative watershed management grant funding was added in 2012 for $3 million, followed by an annual commitment of $3.15 million. This expenditure was matched with an increase in levy revenue.

- Flood District administrative costs have ranged from $500,000 to $600,000 per year.
- Levy suppression payments of $3 million were expended in 2010.
- Revised assumptions about the capabilities of the Howard Hanson Dam underscored the need for rebuilt levees in the Lower Green River valley.
- The Black River Pump Station may require replacement.

To date, the new expenditures listed above have been accommodated by deferring capital project costs to later years.

Projected Financial Plan

Existing dedicated sources for funding the Action Plan are the King County Flood Control District, the Inter-County River Improvement Fund, and external grants. Table 7-5, inserted at the end of this chapter, shows the projected financial plan, drawing upon these funding sources. This projected financial plan assumes continued annual adoption of the Flood District levy, including new construction and annual increases of 1 percent as allowed under Initiative 747. The exemption from property tax suppression expires in 2018; it is assumed that suppression will not occur. Grant revenues are based on known and contracted grant sources for 2013-2015 and an estimate of $1 million per year in subsequent years.

Designated Emergency Fund

When the District was initiated, the required available fund balance for emergency and insurance purposes was $2.5 million. That amount later increased to $3.5 million. In 2012 it increased again, to $7.5 million, based on guidance from King County's Office of Risk Management.

LOCAL, STATE AND FEDERAL PARTNERSHIPS

This section updates local, state and federal programs that provide funding opportunities for flood risk reduction activities. Examples of activities funded through these programs since 2006 are included in the accomplishments section of Chapter 5 for each basin.

King County Mitigation Reserves Program

The King County Mitigation Reserves Program is a King County-sponsored program through which those whose projects create unavoidable impacts on aquatic resources can pay a mitigation fee in lieu of completing their own mitigation. King County then uses fees to implement mitigation projects. The program complies with federal rules for compensatory mitigation issued in April 2008 by the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency (Title 33 Code of Federal Regulations Part 332 and Title 40 Code of Federal Regulations Part 230) defining an in-lieu fee program as follows:

> "a program involving the restoration, establishment, enhancement, and/or preservation of aquatic resources through funds paid to a governmental or non-profit natural resources management entity to satisfy compensatory mitigation requirements... Similar to a mitigation bank, an in-lieu fee program sells compensatory mitigation credits to permittees whose obligation to provide compensatory mitigation is then transferred to the in-lieu program sponsor."

It is possible that fees paid through the Mitigation Reserves Program could fund implementation of the Action Plan. As of 2012, Mitigation Reserves Program funding is being considered for the Elliott Bridge project on the Cedar River as mitigation for the State Route 520 expansion. There are several considerations related to using mitigation fee payments to implement projects:

- Certain funding sources for acquisitions or project implementation do not allow use of supplemental mitigation funding.
- Any mitigation project must be clearly defined as such and must be discrete from project elements implemented with other funding sources.
- Mitigation projects may have special requirements for performance standards, monitoring and maintenance, and adaptive management plans.
- Land where mitigation projects occur must be permanently protected by conservation easements or similarly protective restrictive covenants.
- Mitigation payments result from impacts on aquatic resources; these impacts should be recognized when analyzing cumulative impacts and restoration in a watershed context.

A more detailed description of the King County Mitigation Reserves Program and program documents can be found at: http://www.kingcounty.gov/environment/waterandland/wetlands/mitigation-credit-program.aspx

CONCLUSION AND RECOMMENDATION

With the creation of the King County Flood Control District and establishment of a countywide levy to fund District activities, King County and the King County Flood Control District are better able to provide regional, comprehensive flood hazard management services that help reduce public safety risks from flooding and channel migration. However, new regional floodplain management costs have been added to the District's work program since its creation in 2007. These include flood damage repair costs, the creation of the Sub-Regional Opportunity Fund, cost-share funding for the Elliott Bay Seawall, installation and removal of 26 miles of sandbags along the Green River, and funding for watershed management grant programs, among others.

It is the recommendation of the 2013 Flood Plan Update to continue funding the District at a level that ensures long-term funding of flood risk reduction actions. These actions will protect lives, public and private properties, regional economic centers and transportation corridors, natural resources, and prime agricultural soils.

TABLE 7-5.
2013-2018 FLOOD DISTRICT FINANCIAL PLAN

King County Flood District Financial Plan: 2013-2018

	2011 Actual	2012 Proposed	2012 Revised	2013 Proposed	2014 Proposed	2015 Projected	2016 Projected	2017 Projected	2018 Projected
Beginning Balance	39,820,379	5,103,137	49,509,839	55,044,160	47,597,840	29,866,354	14,378,956	7,522,489	9,041,534
Revenue									
Flood District									
Flood District Levy [1]	35,962,280	36,302,192	36,527,188	41,346,031	42,015,005	42,682,422	42,364,281	43,067,204	43,794,887
Interest Earnings [2]	258,965	321,942	266,734	274,736	282,979	291,468	300,212	309,218	318,495
Miscellaneous Revenue [3]	193,257								
King County									
Delinquent River Improvement Fund Levy	1,000								
Inter-County River Improvement [4]	45,359	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Grants	2,514,314	4,070,000	12,681,658	1,736,261	2,000,000	2,775,000	1,000,000	1,000,000	1,000,000
Total Revenue	38,975,176	40,744,134	49,525,581	43,407,028	44,347,984	45,798,890	43,714,493	44,426,422	45,163,382
Expenditure									
District Administration [5]	(645,160)	(687,864)	(687,864)	(592,190)	(579,056)	(596,427)	(614,320)	(632,750)	(651,732)
Levy Suppression Payment [6]	(3,090,823)								
Operating Expenditure	(5,969,528)	(8,368,689)	(9,027,919)	(9,913,606)	(9,527,523)	(9,130,606)	(9,404,524)	(9,686,660)	(9,977,260)
Capital									
New Capital Appropriation			*(39,690,843)*	*(38,248,015)*	*(66,181,635)*	*(39,596,089)*	*(29,544,976)*	*(18,698,735)*	*(16,721,403)*
Carryover			*(45,997,847)*	*(51,413,214)*	*(49,313,676)*	*(63,522,421)*	*(51,559,255)*	*(40,552,116)*	*(26,662,883)*
Expenditure Rate			*40%*	*45%*	*45%*	*50%*	*50%*	*55%*	*60%*
Capital Expenditure [7]	(19,580,206)	(30,025,046)	(34,275,476)	(40,347,553)	(51,972,890)	(51,559,255)	(40,552,116)	(32,587,968)	(26,030,572)
Total Expenditure	(29,285,716)	(39,081,599)	(43,991,259)	(50,853,349)	(62,079,469)	(61,286,289)	(50,570,960)	(42,907,377)	(36,659,564)
Ending Balance	49,509,839	6,765,672	55,044,160	47,597,840	29,866,354	14,378,956	7,522,489	9,041,534	17,545,352
Target Fund Balance	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*
Carryover Reserves	*(45,997,847)*		*(51,413,214)*	*(49,313,676)*	*(63,522,421)*	*(51,559,255)*	*(40,552,116)*	*(26,662,883)*	*(17,353,714)*
Ending Undesignated Fund Balance	*3,511,992*		*3,630,947*	*(1,715,836)*	*(33,656,067)*	*(37,180,299)*	*(33,029,627)*	*(17,621,349)*	*191,638*

Notes:

1 Property tax forecast provided by the Office of Economic and Financial Analysis on 7/25/12.

2 Interest earnings based on average daily cash balances considering the timing of flood levy receipts and transfers to the operating and capital funds.

3 Miscellaneous revenue due to multiple sources such as state forest sales, private timber harvest tax, rent from tenants of acquired real estate, and immaterial corrections from prior years.

4 The ICRIF amount is based on the 1914 Inter-County Agreement for improvements to the White River.

5 Costs based on contract established under FCD 2008-07 for District executive services, and inflated at 3% in succeeding years.

6 The "Levy Suppression Payment" is the amount paid to senior taxing districts in 2011 to allow the Flood District to continue collecting levy revenue.

7 The capital expenditure is equal to the expenditure rate times the sum of the new capital appropriation and carryover.