Stillaguamish River Comprehensive Flood Hazard Management Plan

North Fork Stillaguamish River near Oso

February, 2004

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Snohomish County
Public Works
Surface Water Management
2731 Wetmore Avenue-Suite 300
Everett, WA 98201-3581

Working together for people, streams & fish.

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Special Acknowledgements

The Stilly Flood Plan Advisory Committee members have significantly contributed to this plan's progress and ultimate success. Their input, timely review of documents, and time and energy given to the development of this plan is greatly appreciated.

In addition to the SFPAC members, the contributions of Mr. Ole Eide, Mr. Nels (Sweed) Bodin, Mr. Stanley Matterand, and Mr. Francis H. Giard, Jr. have greatly enhanced our understanding of the history of flooding in the Stillaguamish River basin. Their willingness to share their experiences as long-time residents in the Stillaguamish River basin was invaluable and sincerely appreciated.

SNOHOMISH COUNTY COUNCIL
SNOHOMISH COUNTY, WASHINGTON

AMENDED ORDINANCE NO. 03-150

ADOPTING THE STILLAGUAMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

WHEREAS, floods on the Stillaguamish River floodplain have historically presented serious threats to public health and safety and have caused millions of dollars worth of damage to public and private properties; and

WHEREAS, the Snohomish County Department of Public Works has developed a Stillaguamish River Comprehensive Flood Hazard Management Plan, the purposes of which are to reduce the threat to public health and safety, minimize property damage from floods, and reduce costs of flood protection to the greatest extent feasible; and

WHEREAS, the Stillaguamish River Comprehensive Flood Hazard Management Plan was developed based on technical analyses; information obtained at public meetings and newsletters; and the recommendation of an advisory committee with representatives of property owners; cities within the Stillaguamish River floodplain; local interest groups, federal, state, and local forest industry; the Tulalip and Stillaguamish tribes; and state and federal agencies responsible for floodplain management; and

WHEREAS, the Snohomish County Council finds that the Stillaguamish River Comprehensive Flood Hazard Management Plan should be adopted as a "comprehensive flood control management plan" for the purposes of Chapters 86.12 and 86.26 RCW;

THEREFORE, BE IT ORDAINED

Section 1. The Executive Proposed Stillaguamish River Comprehensive Flood Hazard Management Plan dated August 2003, a copy of which is attached and incorporated herein by reference, is adopted as the Final Stillaguamish River Comprehensive Flood Hazard Management Plan for the purposes of Chapters 86.12 and 86.26 RCW.

Section 2. The Departments of Public Works and Planning and Development Services are directed to make recommendations on the need for appropriate implementing legislation based on the results of technical studies identified in the plan. If any such legislation affects the County's Growth Management plans and codes, it will be considered according to the procedures in Subtitle 30.7 SCC.

Section 3. The Council intends that capital projects identified in the Stillaguamish River Comprehensive Flood Hazard Management Plan be presented to the Council for inclusion in the county's capital facilities plan developed under RCW 36.70A.130 at such times as the County Executive may deem appropriate.

PASSED this 18th day of February, 2004.

SNOHOMISH COUNTY COUNCIL
Snohomish County, Washington

Chair

ATTEST:

Clerk of the Council, Asst.

(X) APPROVED
( ) VETOED
( ) EMERGENCY

DATE: 2/18/04

County Executive

ATTEST:

Approved as to form only:

Deputy Prosecuting Attorney

D-14

Executive Summary

1.0 Introduction

The Stillaguamish River basin encompasses 684 square-miles in northern Snohomish and southern Skagit counties. This Stillaguamish River Comprehensive Flood Hazard Management Plan (Stilly Flood Plan) evaluates flood hazards in the Stillaguamish River basin and identifies flood hazard mitigation opportunities.

2.0 Floods and Flood Hazards

The Stillaguamish River basin is composed of three subbasins including the North Fork, South Fork, and Mainstem. Flooding in the Stillaguamish River primarily occurs between November and February each year. These events generally occur when warm wind and rains follow heavy snowfall in the mountains. These events usually occur between 1,000 and 3,000 feet above sea level in an area known as the rain-on-snow zone. These "rain-on-snow" events cause the river to rise rapidly and result in fast flows. Almost one-half of the North Fork and South Fork subbasins each is considered to be in this transition zone.

These fast flows lead to accelerated bank erosion and increased sediment transport issues in the upper basin with inundation (deep, slower flows) of farmlands on the mainstem. The fast flows increase the potential of dramatic channel changes (i.e., avulsion), rapid or accelerated loss of riverbank (hundreds of feet can be lost to the river in one flood event), and cause large amounts of debris to be swept into the river. In addition, sediment transported down the river can build up around constrictions, such as bridges, increasing maintenance requirements.

The actions developed in this comprehensive flood plan address flood hazards resulting from potential causes of flooding in the Stillaguamish River basin, address immediate threats to residents, and reduce future flood damages.

3.0 Goals

This plan establishes goals for addressing these flood hazards. The goals were developed with the guidance of the Stilly Flood Plan Advisory Committee (SFPAC), which included federal, state, and local representatives. The goals are as follows:

1. Save lives and reduce public exposure to risk;
2. Reduce or prevent damage to public and private property;
3. Reduce historic and prevent future adverse natural resource impacts of flood hazard management;
4. Reduce the costs associated with flood hazard management; and,
5. To the maximum extent possible, allow and encourage natural floodplain processes.

The success of this plan should be judged on how well the recommended actions achieve these goals. The plan also recognizes that flood hazard actions must be consistent with state and federal laws that protect natural resource and environmental values.

4.0 Priorities

The SFPAC used the following priority criteria to determine projects to be implemented first:

Priority 1 Action - Actions that have a direct impact on saving life and property, would be initiated immediately (included in the 2003 FCAAP cycle), or must be completed before other actions can be initiated;
Priority 2 Action - Actions that follow completion of another recommended action and would most likely be pursued with funding assistance from the 2005 FCAAP cycle;
Priority 3 Action – Actions that would be initiated when time and money became available or action would benefit from the completion of Priority 1 or 2 actions.

As a result of the SFPAC prioritization process, one of the first priority actions to be implemented is the Flood Insurance Re-Study (RFIS) and associated updated mapping of the floodplain. The results of the computer modeling that will be completed as part of the RFIS will be used as a foundation for other actions outlined in this plan.

5.0 Recommendations

The recommendations addressing basin-wide, subbasin, and site-specific issues including:

Category	Actions
Capital	✓ Implement selected alternatives to protect the City of Stanwood and surrounding area from Stillaguamish and Skagit river flooding; ✓ Acquire and remove ten structures and purchase 28 acres in the floodway of the North Fork Stillaguamish River (Awarded a ~$1.9 million dollar Hazard Mitigation Grant Program grant); ✓ Apply for federal funding to relocate critical facilities on the floodplain of the mainstem Stillaguamish River; ✓ Establish and implement a voluntary home elevation and relocation program.
River Planning	✓ Update the floodplain maps; ✓ Identify high hazard zones throughout the entire river system (i.e., areas of accelerated erosion, high velocities, debris collection sites, deep waters); ✓ Complete detailed feasibility studies of solutions at specific hazard sites.
Forest Practices	✓ Assess the potential impacts of forest practices on peak flows.
Flood Warning and Emergency Response	✓ Install flood warning gages; ✓ Refine information on level of protection provided by existing County flood control structures.
Maintenance and Monitoring	✓ Continue efforts to develop innovative methods for sediment management at County bridges.

6.0 Funding

Currently, County river management activities are primarily funded through a portion of the Real and Personal Property Tax (RPPT) authorized by RCW 86.12.010. This

Countywide funding source is used for flood hazard planning, bank stabilization, and maintenance and repair of flood control structures. The allocation of this countywide funding source to flood projects is very limited and additional funding sources would need to be obtained to fully implement this plan. Available funding sources include federal, state, and local programs in addition to a variety of grant opportunities.

The table on the following pages details each recommended action, its priority as established by SFPAC, the estimated cost to complete each action, implementing agency, and implementation timeline.

7.0 Conclusion

Full implementation of this plan will take time. However, committee-established priorities, or any reordering of those priorities established by the Snohomish County Council during plan adoption, would allow those actions that directly impact lives and property (within the appropriate uses of public funds) to be initiated quickly following adoption.

This plan reflects an adaptive management approach in that specific recommendations and a review process are provided to evaluate new flood hazards that may develop after the plan adoption. Annual updates of the status of these and other implemented actions will be developed and available to the public.

This plan was built upon the strong participation and efforts of the committee. Members of the general public also provided significant input that helped shape the 35 recommended actions in this plan. As the plan moves into implementation, continued combined involvement by the public and the organizations and citizens who served on the committee will help ensure long-term success. By working together, Stillaguamish flood hazards and public costs can be reduced while maintaining this river's remarkable natural resource values.

STILLY FLOOD PLAN RECOMMENDED ACTIONS							
#	Recommended Action (RA)	Lead Agency	Estimated Cost ($)	Priority	Potential Funding Source	Implementation Time (once work initiated)	Comments
1	Conduct a Flood Insurance Re-Study (RFIS)	SC - SWM	200,000 to 300,000	1	FEMA/ FCAAP	5 years	Action includes mapping floodplain, updating hydrology and hydraulics (H&H), and submitting final product to appropriate state and federal agencies for approval. The last Flood Insurance Study conducted on the Stillaguamish River was in 1982. H&H work completed as part of this RA be used in other RA's (noted below).
2	Relocate critical facilities	Fire Districts	500,000 per facility	1	HMGP	10 years	Three fire stations are located on the floodplain and are pursuing alternatives to move to upland areas. Encourage applying for HMGP funding when becomes available.
4	Analyze all County-owned flood control structures	SC - SWM	50,000	1	RI	2 years	Engineering components (H&H) from RA1 will be used, in part, to complete this task. Unable to complete task during completion of Stilly Flood Plan due to lack of time and money.
7	Conduct a hydrologic and hydraulic analysis of forest practice impacts on peak flows	SC - SWM	20,000/SNOTEL gage	1	FCAAP/RI	5 years	Hydrology completed as part of RA-1. Includes installing new stream and snow gages. Number of gages (stream or snow) unknown.
8	Establish a study committee to address forest practices	SC-SWM	10,000/year	1	RI	3 years	Establish technical committee to review hydrology model development.
12	Map high hazard zones	SC - SWM & PDS	250,000	1	FEMA/ FCAAP	5 years	Effort to be completed as part of RA1. High hazard areas include areas susceptible to channel migration, bank erosion, high velocities, and deep floodwaters. Funding source will dictate county match requirements.
14	Apply for the National Flood Insurance Program Community Rating System	SC - SWM & PDS	50,000	1	RI	3 years	Develop Repetitive Loss Plan initially - balance of CRS follows.
19	Stabilize Swede Heaven bank and pursue voluntary acquisition of at-risk property to protect County road.	SC - ROADS	305,000	1	RF	2 years	Roads Division pursuing voluntary acquisition and bank stabilization for Swede Heaven Road protection. Work with federal agencies may delay completion.

STILLY FLOOD PLAN RECOMMENDED ACTIONS							
#	Recommended Action (RA)	Lead Agency	Estimated Cost ($)	Priority	Potential Funding Source	Implementation Time (once work initiated)	Comments
20	Pursue voluntary acquisition of Chatham Acres	SC - SWM	1.9 Million	1	HMGP/private	2 years	Application to state in June 2002. Notified in Nov. 2002 that grant forwarded to Federal Emergency Management Agency for funding.
30	Provide improved flood warning on the mainstem	SC-SWM, SC-DEM	5,000/gage/yr	1	RI	on-going	Underway. New flood warning gages installed on Interstate 5 and on Pioneer Hwy.
32	Elevate Big Ditch Road to provide Skagit River flood protection to the City of Stanwood	Corps, City of Stanwood, SC, FCD	1.5 million	1	Corps/COS/ FCD/FCAAP	5 years	Estimated cost for construction of Big Ditch Levee only (north option). If project pursued under Corps authority, cost share at 65% Corps/35% local. Otherwise effort to be funded entirely from local partners. Continues to be a high priority.
33	Implement scaled-down Irvine Slough solution and post-flood drainage actions	Corps, City of Stanwood, SC, FCD	$600,000 to $1.2 million	1	Corps/COS/ FCD/FCAAP	5 years	If project pursued under Corps authority, cost share at 65% Corps/35% local. Otherwise effort to be funded entirely from local partners. Continues to be a high priority.
3	Establish a voluntary elevation/relocation program	SC - SWM	50,000/Elevation 200,000/Acquistion	2	RI	1 year	Initial mailer to identify interested parties. Establish prioritization criteria to determine acquisition or relocation priorities.
5	Investigate enhancing flood storage on public lands.	SC - SWM, Parks, Roads	20,000 (study only)	2	RI	1 year (investigate) and 5-10 years implementation	Work includes evaluating County parks (e.g., Cloverdale Park, Cicero Park) for flood storage or conveyance potential. Requires H&H results from RFIS work for full analysis.
6	Assist public with technical design and permitting requirements associated with CBSP	SC - SWM	20,000/year	2	RI	1 year/request	CBSP is an effective program in helping private property owners with bank stabilization issues that have a public benefit. This RA is aimed at setting the foundation to assist residents through permitting and technical review processes (John review).
9	Using the modeling results from the RFIS, conduct a zero-rise floodplain assessment to use as the technical basis for consideration of zero-rise provisions in the county code.	SC - PDS	50,000	2	RI	5 years	Consider action following collection and evaluation of H&H data collected in RA1.

STILLY FLOOD PLAN RECOMMENDED ACTIONS							
#	Recommended Action (RA)	Lead Agency	Estimated Cost ($)	Priority	Potential Funding Source	Implementation Time (once work initiated)	Comments
10	Develop a landslide homeowner education program	SC - PDS	10,000	2	RI	1 year	Develop targeted outreach program that highlights the benefits of retaining vegetation on slopes, minimizing stormwater drainage problems, and other issues relevant to living near steep slopes.
11	Promote voluntary incentives to continue low density floodplain use	SC - PDS	50,000	2	RI	3 years	Continue to promote low density floodplain use to minimize the risk to life and property.
13	Use the mapped high hazard zones as the technical basis for consideration of high hazard zone provisions in the County code.	SC - SWM PDS	50,000	2	RI	5 years	As part of RA1, high hazards zones (areas susceptible to accelerated erosion, high velocities, or deep flow) will be identified for use in developing future County code provisions.
18	Implement results of the SWM bedload study to eliminate need for continued annual dredging under, near, or around bridges.	SC - Eng. Services/SWM	10,000/study	2	RF	3 - 5 years	Bridges to several major tributaries of the Stillaguamish River are maintained by annual dredging. These tributary systems are being evaluated to determine if another less costly method of bridge maintenance is possible. These studies to form the framework for future assessment of bridge maintenance. If a new bridge is recommended, project implementation timeline will depend on staff and funding.
21	Implement Steelhead Haven Landslide stabilization project to meet public safety goals.	Corps, Stillaguamish Tribe	Unknown	2	Tribes/Hab/ Corps	7 - 10 years	Proposal under development by tribal, state, and federal agencies. Estimated costs between 1 million to 10 million depending on which alternative is selected.
24	Conduct a detailed study in the Deer Creek/Oso Area and implement findings.	SC - SWM	150,000	2	RI/FCAAP	3 years once funded.	Installation of flood warning system on Deer Creek can be completed prior to completion of detailed study. Additional detailed work could be completed under FCAAP funding.
26	Remove one log per year to dismantle Black Creek splash dam	SC - SWM, USFS	50,000	2	USFS/RF/RI/ REET	7 - 10 years	15,000 for feasibility study. 5,000 each year until removed

STILLY FLOOD PLAN RECOMMENDED ACTIONS							
#	Recommended Action (RA)	Lead Agency	Estimated Cost ($)	Priority	Potential Funding Source	Implementation Time (once work initiated)	Comments
27	Ensure Gold Basin Landslide stabilization project meets public safety goals	USFS, Corps, SC	Unknown	2	USFS/Tribes/ Hab/Corps	10 years	On-going. Multiple federal, state, and local agencies involved.
31	Conduct an avulsion risk assessment of Dike Road dike and berm; implement findings	SC - SWM, Corps	40,000	2	FCAAP/RI/ REET	3 years	$40,000 for risk assessment and costs for implementation unknown.
15	Evaluate new flood hazards using committee-adopted process	SC - SWM	25,000/hazard (assuming RA1 complete)	3	RI	Annually	This RA enables the Stilly Flood Plan to be a living document. The project evaluation criteria approved by the Planning Advisory Committee as part of the Stilly Flood Plan process would be used to develop, evaluate, and implement solutions for new hazards.
16	Participate in habitat restoration projects that provide cumulative flood reduction benefits	SC - SWM	25,000/project (assuming RA1 complete)	3	Hab/RI	Annually	This RA enables the Stilly Flood Plan to be a living document. The project evaluation criteria approved by the Planning Advisory Committee as part of the Stilly Flood Plan process would be used to develop, evaluate, and implement solutions for new habitat restoration projects that may have a flood reduction benefit.
17	Reestablish floodplain connectivity between the river and side channels through the White Horse Trail where possible	SC - SWM, Parks	25,000/project (assuming RA1 complete)	3	RI/GF/REET	Annually	On-going evaluation of opportunities when they become available. Technical analysis of site specific areas conducted with RA-1 or after modeling complete.
22	Complete engineering assessment to stabilize Bradley Site bank, improve habitat, and reduce potential damage to public infrastructure.	SC-SWM , PW, Parks	150,000	3	RI/RF/REET/ WSDOT	3 years	Bradley site located on the North Fork Stillaguamish upstream of the trestle and SR530 bridge just east of Oso. Initial assessment drafted in the late 1990s. Reevaluate to determine if existing conditions are similar and if so, pursue funding for implementation actions.
23	Investigate feasibility of moving main flow of river at Skagland Hole through upstream	SC - Parks, SWM, WSDOT	40,000 (Feasibility Study)	3	Hab/RI	5 years	Area has also been referred to as Hazel Hole. State Route 530 (state) & WhiteHorse Trail (County) currently impacted by river. Work must be completed in conjunction with state and local property owners.

STILLY FLOOD PLAN RECOMMENDED ACTIONS							
#	Recommended Action (RA)	Lead Agency	Estimated Cost ($)	Priority	Potential Funding Source	Implementation Time (once work initiated)	Comments
	abandoned channel.						
25	Determine flood damage reduction benefits of acquiring Smokes Brother's Farm and removing dike.	SC - SWM, Parks	30,000 for assessment/ 1.5 million if purchase	3	Hab/RI	1 year (following completion of required components of RA1)	Determine using FIS model results. If pursued, acquisition => $1.5 million. Benefits can be determined following H&H work for RA1.
28	When requested by Robe Valley Community through CBSP, work cooperatively to stabilize bank	SC - SWM	50,000	3	RI/REET	1 - 2 years following submittal of CBSP application.	Need cooperation of community, estimated cost of materials authorized up to $10,000. Balance of effort primarily staff time to conduct engineering technical assistance and guidance through the permitting and construction efforts. Community organization could shift priority.
29	End formal maintenance agreement with Corps on Robe Hill Dike and determine whether to remove, modify, or leave as is	SC - SWM	5,000	3	RI/REET	1 year following completion of required components of RA1	H&H technical work completed as part of RFIS(RA1).
34	Investigate methods for flood hazard reduction as part of restoration efforts in Portage Creek	SC Parks, SC-SWM, Corps, Arlington	206,000	3	Hab/RI	on-going	Work closely with Parks, habitat specialists, Arlington and Corps to ensure that water quality improvements are not compromised for flood reduction.
35	Address upland stormwater impacts to lower Church Creek.	SC-SWM, FCD	30,000 - 60,000	3	Hab/RI	on-going	Cost for feasibility study to determine issues such as sedimentation, reduced water quality, and management of water quantity of the floodplain portion of Church Creek. Effort must also consider tide gate improvements planned at mouth of creek.

HOW PRIORITIES WERE ESTABLISHED...	ACRONYMS			
1 - Recommended Action will save lives (direct), initiate immediately, must precede other actions	*CTP*	Cooperative Technical Partner	*REET*	Real Estate Excise Tax
2 - Actions initiated using 2005 FCAAP funds or that follow completion of priority 1 actions.	*FCAAP*	Flood Control Account Assistance Program	*Corps*	U.S. Army Corps of Engineers
3 - Actions initiated when time and money are available or that may benefit from completion priority 1 or 2 actions.	*Hab*	Habitat related grants (e.g., SRFBRD)	*USFS*	US Forest Service
	FCD	Stillaguamish Flood Control District	*HMGP*	Hazard Mitigation Grant Program
	COS	City of Stanwood	SC - SWM	Snohomish County Surface Water Management
	RF	Road Fund	*SC - Parks*	Snohomish County Parks and Recreation
	Tribes	Stillaguamish Tribes	*SC - Roads*	Snohomish County Roads
	WSDOT	Wa. State Dept of Transportation	*SC - PDS*	Snohomish County Planning and Development Services
	CWD	Clean Water District	*DEM*	Snohomish County Department of Emergency Management
	RI	River Improvement	*CBSP*	Cooperative Bank Stabilization Program

Determination of how Stillaguamish River Comprehensive Flood Hazard Management Plan meets requirements in RCW 86.12.200 and WAC173.145.040		
Regulation	*Description*	*Comments*
86.12.200(1)	Designation of areas that are susceptible to periodic flooding, from inundation by bodies of water or surface water runoff or both, including the river's meander belt or floodway.	Recommended actions are provided in Chapter 7. Chapter 3 describes the Flood Warning System and areas periodically inundated during flood events.
86.12.200(2)(a)	Determine need and location of flood control improvements to protect or preclude flood damage to structures	Issue Papers 1 and 2 (Appendices B and C) were developed and the results incorporated in Chapter 7
86.12.200(2)(b)	Establish the level of flood protection that each portion of the system of flood control improvements will be permitted	Addressed in Chapter 7.
86.12.200(2)(c)	Identify alternatives to in-stream flood control work	Addressed in Chapter 7.
86.12.200(2)(d)	Identify areas where flood water could be directed during a flood to avoid damage to buildings	Addressed in Chapter 7.
86.12.200(2)(e)	Identify sources of revenue that will be sufficient to finance the comprehensive scheme of flood control protection and improvements.	Possible sources provided in a matrix in Executive Summary. Outside federal, state, and local funding support will be necessary to fully implement plan.
86.12.200(3)	Establish land use regulations that preclude location of structures, etc., in flood prone areas	SCC already has in place a body of policies and regulations that together satisfy floodplain development/land use requirements of this RCW. Table 1, *SC Policies and Regulations that Support RCW 86.12* is provided in Appendix D.
86.12.200(4)	Establish restrictions on construction activities in areas subject to periodic floods that require flood proofing of those structures permitted for construction or remodel	SCC already has in place a body of policies and regulations that together satisfy floodplain development/land use requirements of this RCW. Table 1, *SC Policies and Regulations that Support RCW 86.12* is provided in Appendix D.
86.12.200(5)	Establish restrictions on land clearing activities and development practices that exacerbate flood problems (excluding forest practices)	SCC already has in place a body of policies and regulations that together satisfy floodplain development/land use requirements of this

Determination of how Stillaguamish River Comprehensive Flood Hazard Management Plan meets requirements in RCW 86.12.200 and WAC173.145.040		
Regulation	*Description*	*Comments*
		RCW. Table 1, *SC Policies and Regulations that Support RCW 86.12* is provided in Appendix D.
173.145.040(1)	Determination of need for flood control work	Addressed. (Chapter 1)
173.145.040(1)(a)	Description of watershed	Addressed. (Chapter 2)
173.145.040(1)(b)	Identification of types of watershed flood problems	Issue Papers 1 and 2 (Appendices B and C) were developed and the results incorporated in Chapter 7
173.145.040(1)(c)	Location and identification of specific problem areas	Issue Papers 1 and 2 (Appendices B and C) were developed and the results incorporated in Chapter 7
173.145.040(1)(d)	Description of flood damage history	Addressed. (Chapter 6)
173.145.040(1)(e)	Description of potential flood damages	Addressed. (Chapter 6)
173.145.040(1)(f)	Short-term and long-term goals and objectives for the planning area	Addressed. (Chapter 7)
173.145.040(1)(g)	Description of rules that apply within the watershed including, but not limited to, local shoreline management master programs, and zoning, subdivision, and flood hazard ordinances	Addressed. A description of relevant federal, state, and local rules and regulations that may apply are provided in Appendix.
173.145.040(1)(h)	Determination that the in-stream flood control work is consistent with applicable policies and rules	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(2)(a)	Alternative flood control work – description of potential measures of in-stream flood control work	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(2)(b)	Description of alternatives to instream flood control work	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(3)(a)	ID and consideration of potential impacts of instream flood control work on fish resources	No in-stream work is proposed in plan. Rather, determining feasibility of

Determination of how Stillaguamish River Comprehensive Flood Hazard Management Plan meets requirements in RCW 86.12.200 and WAC173.145.040		
Regulation	*Description*	*Comments*
		certain actions is proposed before in-stream activities can be conducted.
173.145.040(3)(b)	ID and consideration of potential impacts of instream flood control work on wildlife resources	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(3)(c)	ID and consideration of potential impacts of instream flood control work on scenic, aesthetic, and historic resources	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(3)(d)	ID and consideration of potential impacts of instream flood control work on navigation	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(3)(e)	ID and consideration of potential impacts of instream flood control work on water quality	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(3)(f)	ID and consideration of potential impacts of instream flood control work on hydrology	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(3)(g)	ID and consideration of potential impacts of instream flood control work on existing recreation	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be conducted.
173.145.040(3)(h)	ID and consideration of potential impacts of instream flood control work of other impacts	No in-stream work is proposed in plan. Rather, determining feasibility of certain actions is proposed before in-stream activities can be

Determination of how Stillaguamish River Comprehensive Flood Hazard Management Plan meets requirements in RCW 86.12.200 and WAC173.145.040		
Regulation	*Description*	*Comments*
		conducted.
173.145.040(4)	Area of coverage shall be at a minimum the 100-year floodplain, but may include an entire watershed. Comprehensive plans shall include flood hazard areas not subject to riverine flooding such as areas subject to coastal flooding, flash flooding, or flood from inadequate drainage. Either the meander built or floodway must be identified on aerial photographs or maps that will be included in the plan.	This is a watershed-based plan with coastal flooding addressed. Aerial photographs need to be included.
173.145.040(5)(a)	Evaluation of problems and needs	Issue Papers 1 and 2 (Appendices B and C) were developed and the results incorporated in Chapter 7
173.145.040(5)(b)	Evaluation of alternative solutions	Issue Papers 1 and 2 (Appendices B and C) were developed and the results incorporated in Chapter 7
173.145.040(5)(c)	Recommended corrective action with proposed impact resolution measures for resources losses	Issue Papers 1 and 2 (Appendices B and C) were developed and the results incorporated in Chapter 7
173.145.040(5)(d)	Corrective action priority	Issue Papers 1 and 2 (Appendices B and C) were developed and the results incorporated in Chapter 7
173.145.040(6)	A certification from the State Department of Community, Trade, and Economic Development (now Office of Community Development) that the local emergency management organization is administering an acceptable comprehensive emergency operation's plan.	Appendix I.

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CHAPTER 1

INTRODUCTION

CHAPTER 1 – INTRODUCTION

1.0 Purpose

Like all rivers, the Stillaguamish River is subject to regular flooding. While flooding is a natural occurrence that benefits the environment, it poses a potential hazard to county residents who live on the floodplain and lowlands. In the 1990s, Snohomish County residents experienced several devastating floods (2 in 1990, one each in 1995, 1996, and 1997), four of which were declared natural disasters. As a result of those floods, Snohomish County initiated this Stillaguamish River Comprehensive Flood Hazard Management Plan (Stilly Flood Plan) to identify areas that may contribute to increased flood damages and determine actions that can be taken to reduce those damages while preserving the positive environmental effects of flooding.

1.1 Study Area

This 684 square mile basin is located in Snohomish and Skagit counties in northwest Washington (Figure 1). The study area is the Stillaguamish River *basin* (Figure 2). Causes of flooding are evaluated on a basin scale while symptomatic effects are addressed on the floodplain of the mainstem and two major forks.

> ***Basin*** is the area within which all surface water – whether from rainfall, snowmelt, springs, or other sources - flows to a single water body or water course. The boundary of a river basin is defined by natural topography. Also known as a ***Watershed*** or ***Drainage Basin.***

1.2 Plan Organization

This document identifies watershed and flooding characteristics, flood hazard areas, flood storage and conveyance areas, flood hazard management options, and recommended actions.

The Stilly Flood Plan is organized as follows:

- ✓ Chapter 1 presents the flood management plan requirements, the process used to develop this plan, and outlines information pertaining to Flood Control Account Assistance Program (FCAAP).
- ✓ Chapter 2 provides information about Stillaguamish River basin characteristics.
- ✓ Chapter 3 provides fundamental information on flooding, hydrology, and sedimentation.
- ✓ Chapter 4 provides information on the County's Flood Warning System. This chapter also provides general information of flood patterns in the Stillaguamish River basin.
- ✓ Chapter 5 documents the history of major Stillaguamish River flood events.
- ✓ Chapter 6 outlines the history of floodplain management efforts taken to protect property from flood damages and discusses previous studies of flooding and flood

management on the Stillaguamish River. It also documents the impacts of those efforts on habitat.

- ✓ Chapter 7 analyzes flood hazards and flood hazard reduction opportunities. Alternative actions are evaluated and preferred recommended actions provided.
- ✓ Appendices contain the following:
  - o Appendix A: Acronyms
  - o Appendix B: Issue Paper # 1, an analysis of selected forest practices and their impacts on flooding in the basin;
  - o Appendix C: Issue Paper #2, a detailed analysis of identified flood hazards and flood hazard mitigation opportunities in the basin;
  - o Appendix D: Descriptions of applicable federal, state, and local regulations;
  - o Appendix E: Funding opportunities for implementation efforts;
  - o Appendix F: Meeting summaries from the Stilly Flood Plan Advisory Committee; and,
  - o Appendix G: Additional graphics.
  - o Appendix I: Letter from the Washington State Emergency Management Division certifying that the local emergency management organization is administering an acceptable comprehensive emergency operation's plan.

1.3 Required Plan Elements and Funding Benefits

The plan follows state requirements regarding the preparation of flood hazard plans and conforms to the following procedures described in Revised Code of Washington (RCW) 86.26 and Washington Administrative Code (WAC) 173-145 (Appendix D):

- ✓ Establish a citizen and agency participation process;
- ✓ Set short- and long-term goals and objectives for flood hazard management;
- ✓ Develop an inventory and analysis of physical conditions;
- ✓ Determine the need for and identify alternatives for flood hazard management measures;
- ✓ Evaluate alternative measures;
- ✓ Hold public workshops for evaluation of alternatives;
- ✓ Complete the draft Stilly Flood Plan and associated documentation;
- ✓ Submit the final Stilly Flood Plan to the Washington State Department of Ecology (Ecology);
- ✓ Hold a public hearing and adopt the Stilly Flood Plan; and,
- ✓ Notify Ecology that the Stilly Flood Plan was adopted.

Once Ecology has reviewed this plan, implementation actions will be eligible for state funding through the FCAAP.

Figure 1: Vicinity Map for Snohomish, Washington.

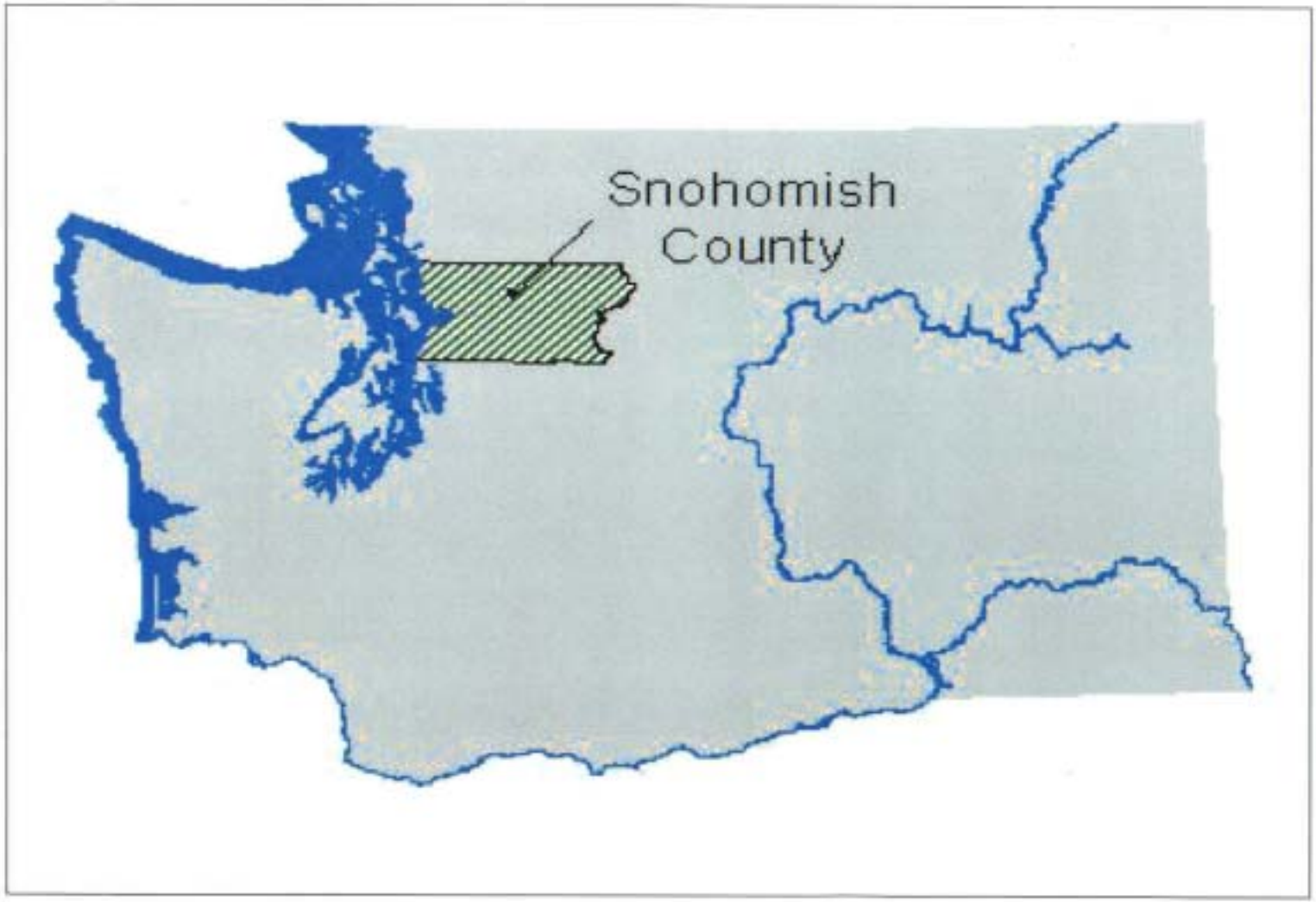
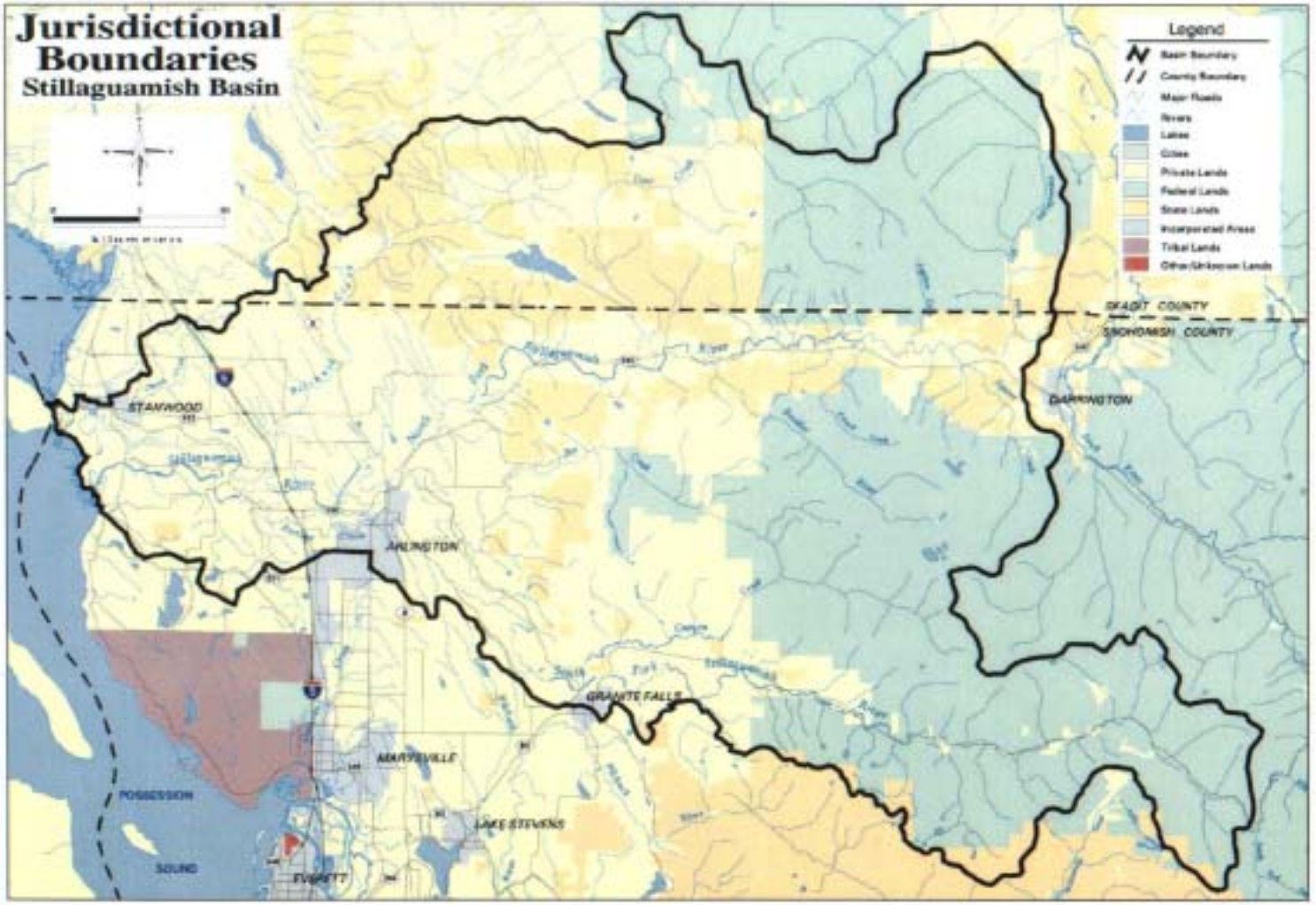


Figure 2: Stillaguamish River Basin in Snohomish County, Washington.



1.4 Public Involvement

Public involvement is critical to the success of flood hazard management planning. Proposed measures may affect local property owners. Their feedback throughout the effort is needed to develop actions. The planning process also offers an opportunity to educate the public on the issues, opportunities, and public responsibilities of flood hazard management. Because the local governments must adopt the plan, it is important that local residents take an active role in developing the plan contents.

1.4.0 ADVISORY COMMITTEE

One of the first steps in developing this plan was to establish the Stilly Flood Plan Advisory Committee (SFPAC) to obtain public and agency involvement. The SFPAC consisted of representatives from public and private organizations and agencies (Table 1). SFPAC met five times to provide regular feedback to the County and also reviewed products through e-mail or regular mail.

Representatives from Silvana, the Pilchuck Audubon Society, Duck's Unlimited, the City of Granite Falls, and the Town of Darrington were invited, but did not attend meetings. Representatives from National Oceanic and Atmospheric Administration – Fisheries (NOAA-Fisheries) and from the U.S. Fish and Wildlife Department were also approached. While these representatives were unable to attend meetings, they were provided the same information the SFPAC received throughout the process. The efforts of all the SFPAC members were invaluable to the completion of this plan.

To reduce the amount of review SFPAC was required to do at any one time, the plan was developed and distributed in sections. A background report on the basin (e.g., flood history, previous flood management efforts) was provided to the committee in December 2000. An issue paper on forest practices and their potential impacts on flooding in the basin were distributed at the January 2001 meeting. A second paper was distributed at the March 2001 meeting that identified flood hazards and flood hazard mitigation opportunities in the basin. SFPAC comments were incorporated into these documents and the final issue papers are provided in Appendices B and C.

1.4.1 ADDITIONAL OUTREACH EFFORTS

While SFPAC provided feedback to their respective groups on a regular basis, the County sought additional input from Stillaguamish residents. In September 2000, a fact sheet about the plan and a questionnaire soliciting feedback on personal experiences with flooding and flood hazards were mailed to almost 8,000 residents in the Stillaguamish basin. The County received almost 300 responses to the questionnaire.

In addition to these mailings, two open houses were held in October 2000 to provide information about the Stilly Flood Plan and to obtain additional feedback about potential flooding areas along the Stillaguamish River. Almost 70 residents, elected officials, and agency representatives from the basin attended and discussed their concerns with staff

from Snohomish County, U.S. Army Corps of Engineers, U.S. Forest Service, Washington Department of Natural Resources, Washington Forest Practices Association, City of Stanwood, and the Stillaguamish Flood Control District. Quarterly newsletters were mailed to a list of almost 500 interested residents that provided updates on the study progress. These newsletters and minutes from the SFPAC meetings were placed on the County's river management web page as well.

From May 19 through June 19, 2003, the Stilly Flood Plan was released to the public for their review and comment. The month-long comment period was announced in local newspapers and a newsletter was mailed to those residents who had expressed interest in the plan's development. Open houses, which were advertised in the local papers and in the newsletter, were held on June 5 and June 11, 2003 for residents to talk with SFPAC members about the plan and its 35 recommended actions.

Table 1: Stilly Flood Plan Advisory Committee Members.

Representative	Affiliation
Mr. Bill Blake	City of Arlington
Mr. Chuck Hazelton	Stillaguamish Flood Control District
Mr. and Mrs. Dave & Bobbie Eldridge	Stillaguamish Flood Control District
Mr. Bill Beckman	City of Stanwood
Mr. Paul Cooke (and formerly Mr. Glen Reed)	U.S. Army Corps of Engineers
Mr. Chris Toms	Washington Department of Natural Resources
Mr. Mike Chamblin	Washington Department of Fish and Wildlife
Mr. Dave Burdick/Mr. Chuck Steele	Washington Department of Ecology
Mr. Kurt Nelson	Tulalip Tribes
Mr. Max Albert	Citizen Representative
Mr. Duane Weston	Pilchuck Tree Farm
Mr. Terry Skorheim	US Forest Service, Darrington Ranger District
Mr. Pat Stevenson	Stillaguamish Tribe
Mr. Mike McCallister	Snohomish County Dept. of Emergency Management
Mr. Jeff Chan	U.S. Fish and Wildlife Service
Ms. DeeAnn Kirkpatrick	National Oceanic and Atmospheric Administration – Fisheries

1.5 Plan Approval and Implementation

Following public comment on and revision of this draft plan, it will be forwarded to Ecology for their review and approval. The final plan will then be submitted to the Snohomish County Council for its consideration and adoption. Once the final plan is adopted, implementation of prioritized actions will be initiated based on availability of funds from the FCAAP, County, and other sources.

Full implementation of this plan will take time. However, committee-established priorities will allow those actions that directly impact lives and property to be initiated following County Council adoption. Implementation of all actions will involve the full participation of those who helped develop the plan and others.

Chapter 2

Stillaguamish River Basin Characteristics

CHAPTER 2 – STILLAGUAMISH RIVER BASIN CHARACTERISTICS

2.0 Overview

The Stillaguamish River originates in the Cascade Mountains, flows westward and enters Puget Sound near Stanwood, Washington. The basin is 684 square miles in area and has no dams. The Stillaguamish River basin has three *subbasins* including the North Fork, South Fork, and Mainstem. The North Fork and South Fork Stillaguamish River subbasins are similar in size (284 and 254 square miles, respectively) and in length (47 and 51 river miles, respectively). The forks are generally steep and dynamic so during flood events, bank erosion, high velocities, sediment transport, and debris loading (e.g., tree recruitment) contribute to flood hazards. The forks converge at Arlington, Washington to form the mainstem Stillaguamish River. On the mainstem, flood flows usually slow after spilling onto the large floodplain area.

A ***subbasin*** is a tributary basin of a large drainage basin.

Three quarters of the entire basin is considered forestland, with 90% of the commercially harvestable land in the North Fork and South Fork subbasins. Forest practices, such as road building or harvest rates, increase the potential for altering peak flows in the river and affecting downstream neighbors.

The development density in the Stillaguamish River basin is relatively low. Therefore, managing future development wisely, particularly on the floodplain, is key to reducing the public's exposure to risk and reducing costs associated with on-going flood damages.

2.1 Land Use, Communities, and Environmental Characteristics

2.1.0 BASIN-WIDE

Land Use

Major land uses in the Stillaguamish River basin include forestry, agriculture, and rural residences with smaller areas of urban development. Agriculture and dairy and livestock activities are conducted throughout the basin, but primarily take place on the fertile floodplain of the mainstem.

Almost 75% of the entire Stillaguamish River basin is considered commercially harvestable forestland so how that land is managed can have a significant impact on the basin. A variety of different forestland management techniques are used on these lands based on ownership. The U.S. Department of Agriculture Forest Service, Mount Baker – Snoqualmie Darrington Ranger District (USFS) manages approximately 46% of the commercial forestland in the basin. Washington State Department of Natural Resources (DNR) manages 24% and private landowners manage the remaining 30% of forestland. Details on

forestland management, basin characteristics, and ownership by subbasin are provided in Issue Paper #1, The Effects of Selected Forest Practices on Flooding in the Stillaguamish River Basin, Appendix B.

Existing land use on the North Fork floodplain is a mix of small farms, recreational cabins, and rural residences. Approximately 159 homes are built on the 1,500 floodplain acres on the North Fork zoned as Agriculture-10 (Ag-10) and more than 300 more homes could theoretically be added in the future.

Land use on the South Fork floodplain is primarily recreational cabins, rural residences, and forest. Approximately 435 acres of the floodplain is being used for agricultural purposes. Zoning for this area is designated Ag-10, which has the potential for allowing construction up to 29 new homes. Over 460 acres is zoned Rural Residential where up to 100 new homes might be built in the floodplain in the future. Approximately 185 acres are designated as forest use, which has minimal development potential.

Existing land use on the Mainstem floodplain is primarily agricultural including approximately 9,530 acres of the floodplain agriculture. Zoning for this area is designated Ag-10, which has the potential for allowing construction up to 800 new homes. Approximately 1,540 acres is zoned as Rural Residential where up to 130 new homes might be built on the floodplain.

With the potential of up to 1,000 new homes on the mainstem of the Stillaguamish River, creation of new flood hazards due to floodplain development is one of the biggest issues. The new homes that could potentially be built are almost double the number of today's floodplain homes. Encouraging retention of low density uses on large parcels (such as farmland) is key to preventing future flood damages from occurring.

In this 684 square mile basin, only 32 square miles are in the floodplain of the Stillaguamish of which almost 20 square miles are located on the Mainstem.

Communities

UNINCORPORATED SNOHOMISH COUNTY

Based on the State of Washington's Forecasting Division in the Office of Financial Management, the population in all the unincorporated areas of Snohomish County as of 2001 was 291,142 with estimates of almost 10,000 more people by the year 2002 (http://www.ofm.wa.gov/forecasting/pop.htm).

TOWN OF DARRINGTON

Darrington is located in the northeastern corner of the Stillaguamish River basin. In 2001, the population was estimated at 1,049 residents (web site – Key to the City, http://www.pe.net/~rksnow/wacountydarrington.htm). While part of this Town is in the Stillaguamish River basin, none of its floodplain area is impacted by Stillaguamish flood flows, but rather is impacted by the Sauk River flows.

The major industry in the area is the Summit Timber Mill, which was recently sold to Hampton Mills, Incorporated. It has been in operation since the mid-1900s. The USFS Ranger Station for the Mt. Baker-Snoqualmie National Forest also is in Darrington.

OTHER NORTH FORK COMMUNITIES

In addition to the Town of Darrington, smaller communities including Swede Heaven and Oso have developed along the river. Both of these communities are in unincorporated Snohomish County and are subject to flood damages during flood events. Swede Heaven is near the headwaters of the North Fork Stillaguamish and Oso is near River Mile (RM) 14 where Deer Creek enters the North Fork.

CITY OF GRANITE FALLS

Like Darrington on the North Fork, a portion of the City of Granite Falls is in the Stillaguamish River basin, but none on the Stillaguamish floodplain. The City's floodplain property and Urban Growth Area (UGA) are located in the Pilchuck River basin, which drains to the Snohomish River.

OTHER SOUTH FORK COMMUNITIES

Communities in the unincorporated South Fork Stillaguamish River subbasin include Verlot, Robe Valley, and Silverton, which are all located above Granite Falls.

CITY OF ARLINGTON

The City of Arlington was formed in 1903 and is located at the confluence of the North and South Forks of the Stillaguamish River. Much of the incorporated part of the City is built above the Stillaguamish River floodplain, but a small portion of Arlington's UGA is on the floodplain of the South Fork Stillaguamish. It is anticipated because this area is subject to high velocities and deep flows, the area will not be developed.

CITY OF STANWOOD

Although the City of Stanwood's UGA is predominately above the floodplain, the city proper is located directly on the floodplain. The City is vulnerable to flooding from the Skagit River to the north, the Stillaguamish River to the south, and tidally from the west. The threat from the Skagit occurs if floodwaters overtop the left bank levees (looking downstream) on the river south of Mount Vernon and flow south on the floodplain toward Stanwood. These floodwaters are trapped between sea dikes to the west and natural high ground to the east, and so would flow south all the way to Stanwood where State Route (SR) 532 would obstruct flow and cause significant ponding in the city limits. In 1959 the Skagit overtopped its banks and flowed south, inundating the city. That was the last year the city experienced major flooding.

The threat from the Stillaguamish River occurs when floodwaters overtop SR532. The city currently conducts flood fighting efforts on Marine Drive as it passes under SR532. Further

west, however, a major flood would result in overtoppng over approximately 2,500 to 3,000 feet of SR532. In 1990, the City constructed a 3-foot high sandbag structure along several hundred feet of SR532 to prevent floodwaters from entering the city.

Flood hazards to Stanwood are being addressed in this plan and in a concurrent study being conducted by the Corps in partnership with Snohomish County, Stanwood, and the FCD. This Corps-led Section 205 Small Flood Study (Section 205 Study) is focused on reducing flood damages to Stanwood and surrounding residents from the Skagit River and Stillaguamish River. More information on the Section 205 Study is provided in Chapter 7.

LOCAL IMPROVEMENT OR SPECIAL DISTRICTS

STILLAGUAMISH RIVER FLOOD CONTROL DISTRICT (FCD)

The Stillaguamish FCD was formed on December 9, 1992 under RCW 85.38. The FCD encompasses much of the lower Stillaguamish River floodplain (Figure 3), beginning just south of the intersection of SR530 and Norman Road, west to Marine Drive, and north to the Stanwood City limits and Leque Road. The FCD maintains levees and drainage systems in its service area.

DRAINAGE DISTRICT 7

Diking District 7 is in the Skagit River floodplain, north of the City of Stanwood. This district was formed in the mid-1960s to conduct emergency repair work on the dikes, improve or repair tide gates, and other drainage related efforts in the district. It is composed of four farms.

FEE DISTRICTS

CLEAN WATER DISTRICT

The Lower Stillaguamish River Clean Water District (CWD) is a service area within the Stillaguamish River basin from Port Susan up the North Fork Stillaguamish to approximately RM17 (above Oso) and on the South Fork to the mouth of Canyon Creek (Figure 4). The CWD was created for the purposes of water quality restoration and surface water management services. A board, with representation from both the drainage and flood districts, advises Snohomish County and other agencies on water quality restoration and surface water management services within the Lower Stillaguamish River CWD. A rate structure was established to assess and collect fees based on "land use classification and/or degree of impervious surface coverage." (Snohomish County Code Title 25A.20)

Figure 3: Stillaguamish Flood Control District Boundary.

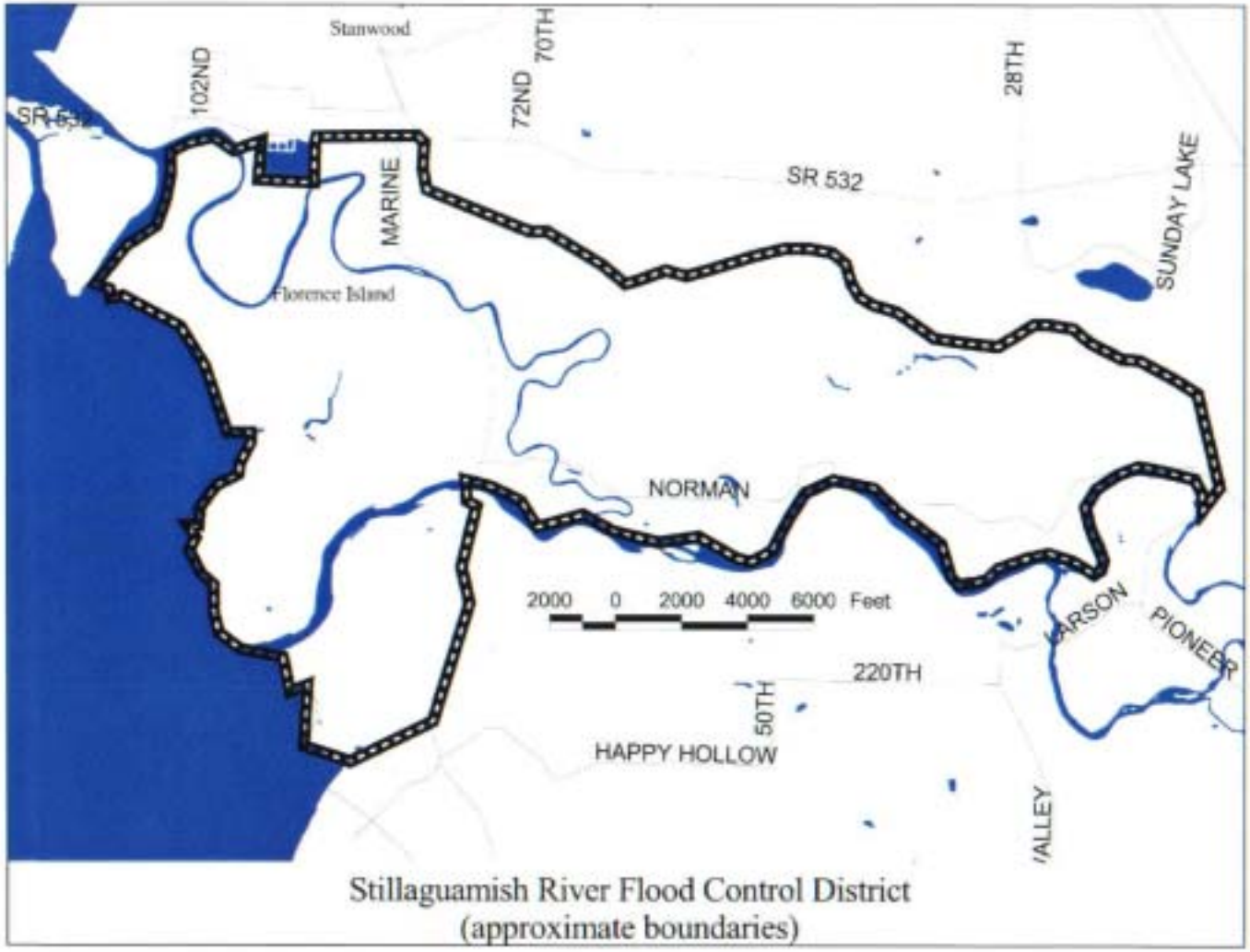
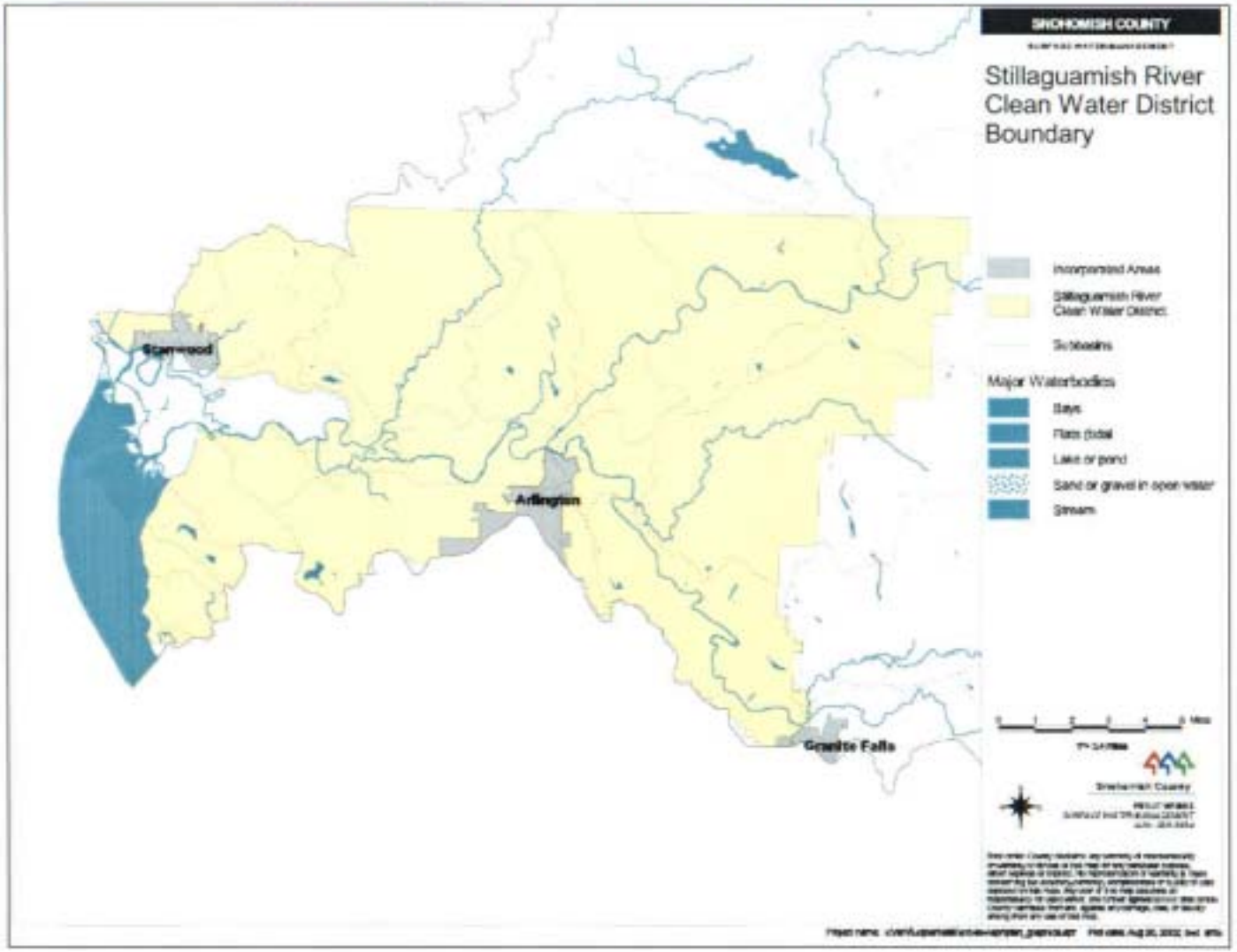


Figure 4: Stillaguamish River Clean Water District Boundary.



Environmental Characteristics

WETLANDS

Wetlands provide functions that support aquatic and terrestrial ecosystems. They also act as a sponge providing flood relief by collecting, storing, and releasing floodwater to the river more slowly than would occur without them. This natural timing mechanism attenuates peak flows and reduces erosion and other the negative effects of rapid flow increases. Wetlands also can improve water quality by removing excess nutrients and other toxicants (National Research Council 1992).

Almost 80% of the historic wetlands in the Stillaguamish River basin have been lost or degraded. The almost 29,200 acres of wetlands that once existed in the basin have been reduced to approximately 6,200 acres. The losses in the upper watershed (i.e., in the North or South Fork subbasins) likely contribute to increased sediment load in the forks and mainstem. The conversion of forested wetlands to drained agricultural land typically resulted in the export of sediment and nutrients as well. Flood storage and conveyance is also impacted through the loss of any wetland (STAG 2000).

WATER QUALITY

The Stillaguamish River has experienced deterioration in water quality from sources such as commercial and non-commercial farms, failing septic systems, land clearing and construction, road surface runoff, and over allocation of water resources (STAG 2000).

Fecal coliform and ammonia have decreased on the mainstem below Arlington in the last 20 years, but suspended sediment, oxygen, temperature, and nutrient levels have not shown similar improvements (Joy and Glenn 2000). Except for high sediment levels, the best water quality in the basin is found in the North and South Forks. Smaller tributaries such as Church, Portage, and Pilchuck creeks, experience water quality issues related to bacteria, dissolved oxygen, temperature (Snohomish County 2000).

Agencies including the USFS, Ecology, and DNR are working with the County to address water quality issues including developing baseline data from which changes in water quality can be assessed. The Stillaguamish Tribe has conducted significant monitoring efforts in the upper basin to document temperature, dissolved oxygen, turbidity, and other factors. The County also has conducted investigations for nutrients, heavy metals, bacteria, and other toxicants to fish mainly in the lower portion of the basin.

Anadromous salmonids are salmon, trout, and char species that migrate between freshwater and saltwater.

SALMONID HABITAT

A variety of *anadromous* salmonid species use the Stillaguamish River system as spawning and rearing ground. In the near-decade between 1956 and 1965, the Stillaguamish contributed an estimated 20% of the total anadromous fish production of the seven largest basins in the region. Species including summer and fall

chinook, fall chum, coho, pink salmon, summer and winter steelhead, anadromous cutthroat trout, anadromous char, and riverine sockeye salmon have been found throughout the system (STAG 2000). More information on salmonids is provided in Chapter 6.

2.1.1 UNIQUE SUBBASIN CHARACTERISTICS

North Fork

The North Fork headwaters begin in the extreme northeast section of the basin in Skagit County. This subbasin is about 41% of the entire Stillaguamish River basin. The North Fork flows into Snohomish County west of the Town of Darrington. Whitehorse Mountain, the highest peak in the North Fork subbasin, is at an elevation of approximately 6,800 feet. The river flows southwesterly for approximately 46 miles near the communities of Swede Heaven and Oso until its confluence with the South Fork at an elevation of 52 feet. The uppermost 16 miles of the North Fork, along with the three major *tributaries*, Squire, Boulder, and Deer creeks, have steep gradients and flow through narrow valleys.

*A **TRIBUTARY** is a creek, stream, or river fork feeding the major water-course in the area.*

South Fork

The South Fork headwaters originate in the southwestern section of the basin at an elevation of 6,200 feet on Vesper Peak. The South Fork subbasin is about 36% of the Stillaguamish River basin. Above the communities of Silverton and Verlot, the South Fork flows in a steep channel before entering a gradually widening 26-mile valley bordered by high mountains. The City of Granite Falls is situated just upstream of Canyon Creek, one of the major tributaries to the South Fork Stillaguamish River. Below Canyon Creek, the South Fork flows northwesterly 12 miles to a narrow flood plain 4 miles above the confluence with the North Fork.

Most of upper South Fork subbasin is in the Mt. Baker-Snoqualmie National Forest. Below Buck Creek, a tributary approximately 20 river miles above Verlot, the gradient decreases from 100 ft/mile to a more gradual 38 feet/mile. Mixed conifers and deciduous forest dominate this area. The channel bottom is predominately gravel, cobble, and boulder.

Below Verlot area, the river enters the Robe Valley Canyon. A fish ladder was constructed in 1954 at Granite Falls near the lower end of the canyon to enable fish access to the upper South Fork. This subbasin is also used for recreation, containing over 30 miles in trails. The old Monte Cristo Railroad was built across Barlow Pass in 1893 and provided transportation to the mining town of Monte Cristo. Remnants of this rail system parallel the river at various locations.

Mainstem

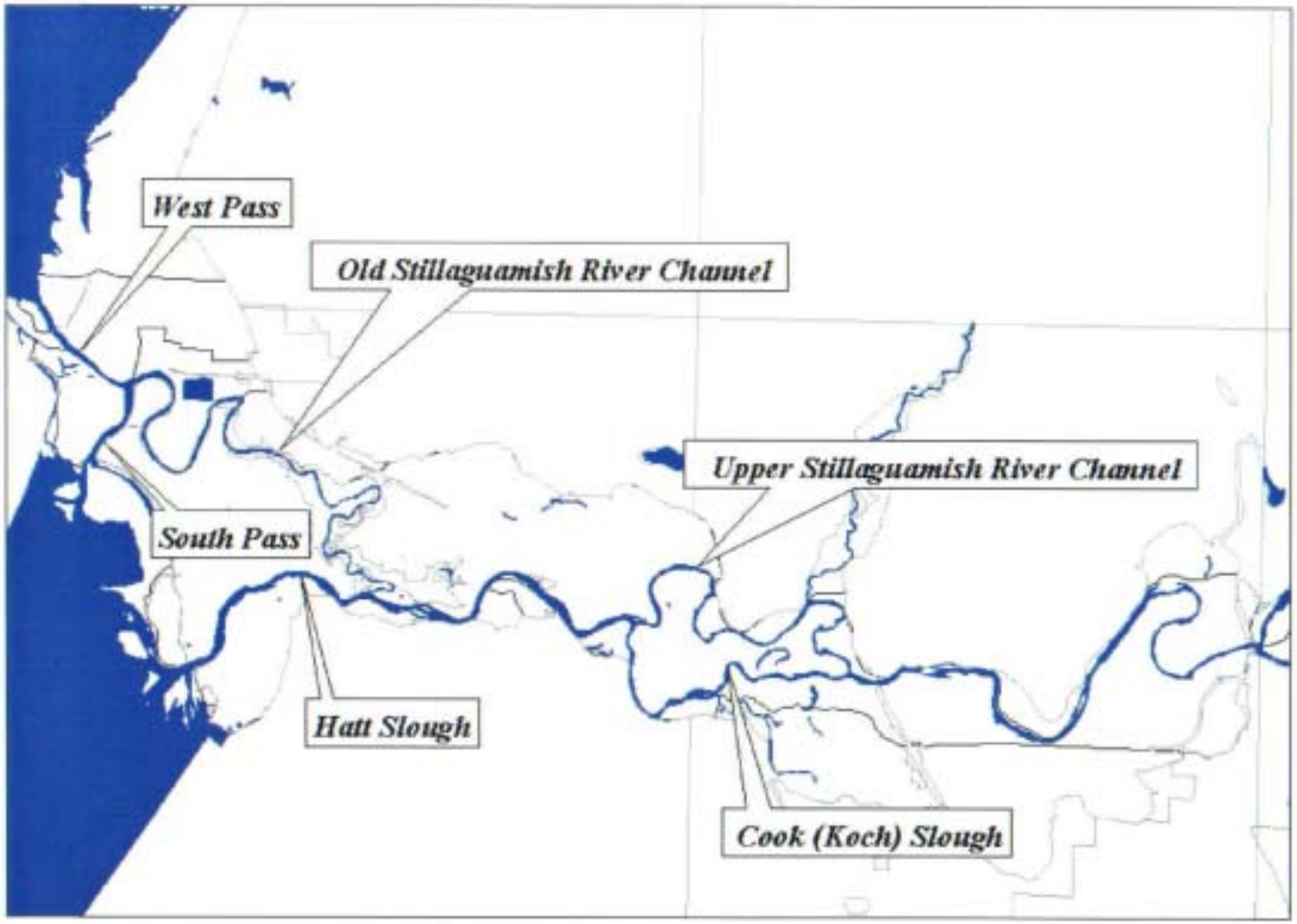
West of Arlington, the mainstem of the Stillaguamish River flows across a broad floodplain approximately 21 river miles to Puget Sound. The mainstem is about 23% of the entire basin. From the confluence of the North and South Fork Stillaguamish, the mainstem flows under Interstate-5 and splits into two channels (Upper Stillaguamish River channel and Cook Slough) forming the island of Silvana (Figure 5). These channels converge back into one main channel west of Silvana. Four miles farther downstream the river splits into the *distributaries* Hatt Slough and the Old Stillaguamish River channel, forming Florence Island. The majority of the water flows down Hatt Slough another four miles into Port Susan. The remaining water travels eight miles down the Old Stillaguamish River channel past Stanwood where it enters Skagit Bay via the West Pass distributary or Port Susan via the South Pass distributary. Pilchuck Creek, which enters the mainstem in the Upper Stillaguamish channel, and Portage Creek, which enter the mainstem in Cook Slough (also referred to as Koch Slough), are the two main tributaries of the mainstem.

> ***DISTRIBUTARIES*** *are branches the river breaks into before it flows in to Puget Sound.*

The Stillaguamish River system is tidally influenced for about 11 miles upstream of its mouth, or about the confluence of the Upper Stillaguamish River and Cook Slough. The total range between *mean higher-high water* and *mean lower-low water* in Puget Sound (at the Seattle gage) is approximately 11 feet.

> ***MEAN HIGHER-HIGH WATER*** *and* ***MEAN LOWER-LOW WATER***
>
> *Each daily tidal cycle has two, unequal highs and lows as a function of the earth's and moon's orbits. The mean of the higher of the two highs is determined based on the consistent annual cycle of tides. The same method applies to the mean of the lower of the two lows.*

Figure 5: Mainstem Stillaguamish River.



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CHAPTER 3

THE FUNDAMENTALS OF FLOODING

CHAPTER 3 - THE FUNDAMENTALS OF FLOODING

3.0 Evaluating Floods

This chapter describes how floods occur, particularly flooding in the Stillaguamish River. Some of the factors that are used to evaluate impacts caused by flooding include the magnitude of the flood (its peak flow rate); the duration of the flood; potential for migration of the river channel; the deposition of sediments; the presence of and failure of levees; land development status (such as the presence of structures that can be damaged); land or crops lost; and the combination of tide and wind.

3.1 Flood Terminology

When describing flood events, engineers, scientists, and others generally refer to a flood's magnitude, duration, and timing. Once these parameters are quantified, the flood's size is designated. The following subsections describe these terms.

3.1.0 FLOOD MAGNITUDE

Floods are a regular, natural occurrence. Large floods have occurred on the Stillaguamish River throughout its recorded history. As a general rule, floods with greater flow rates, or magnitudes, usually caused more damage. Today, however, smaller flood events cause more damage than in past decades. This increased damage is not necessarily because the floods themselves have grown, but because development that is susceptible to flood damage has increased in areas where flooding naturally occurs, including the *floodplain*. As the river aggrades and the floodplain becomes more developed, the smaller magnitude events can cause significant damage. The largest flood on the Stillaguamish River since recording began in 1935 was the November 24, 1990 event, which was the second of two devastating floods that year. Six of the top ten magnitude floods on record have occurred since that time.

*A **FLOODPLAIN** is the land area along the sides of a river that become inundated with water during a flood.*

*Discharge or river flow is commonly measured in **CUBIC FEET PER SECOND (CFS)**. One cubic foot is about 7.5 gallons of liquid. The average low flow discharge of the Stillaguamish River in September is about 700 cfs, which would fill the old Seattle Kingdome in about a day. The average discharge that can occur every couple of years is 24,000 cfs, which would fill the Kingdome in less than an hour.*

U.S. Geological Survey (USGS) gages are used to record Stillaguamish River flows on the North Fork near Arlington and on the South Fork near Granite Falls. The gages record parameters that allow river flow in *cubic feet per second* or *discharge* to be determined.

*For the purposes of floodplain management, the **RECURRENCE INTERVAL** or **FREQUENCY** defines a flood. The 100-year flood, for example, is a flood that statistically has a one-in-a-hundred chance or a one percent chance of occurring in any given year.*

The records from the USGS gages over the years are used to determine the likelihood of floods of a certain magnitude on the Stillaguamish River (measured as a *recurrence interval*). Most rivers have a natural capacity to contain only the 2- or 5-year flood before floodwaters overtop the banks. The statistics on which flood-frequency definitions are based are the records of actual flooding that has taken place in the past. As records continue to be collected over time, flood-frequency estimates are modified to reflect the newest data. In the United States, the 100-year flood is used as a base flood to rate the effectiveness of flood hazard management measures.

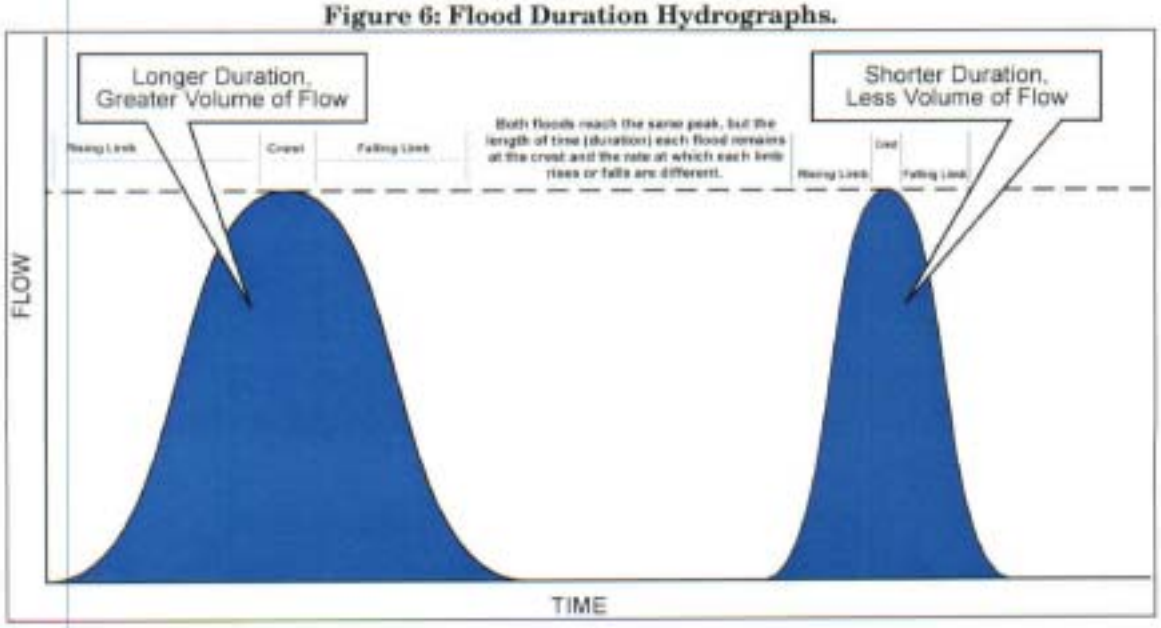
3.1.1 FLOOD DURATION

*A **HYDROGRAPH** is a graphical method used to represent flow over a specified period of time (e.g., hours, days, or months). A hydrograph has a rising limb, crest, and falling limb. The steeper the rising or falling limb, the more rapid the river rises or falls. The longer the crest stays at a certain peak, the greater potential for increased flood damages.*

Floods may have similar peak flows, but floods that remain at that peak for a longer period of time or duration can cause significantly more property damage. Figure 6 contains two *hydrographs*. Hydrographs show the length of time a flood event lasts on the x-axis and flow on the y-axis. Hydrographs can also indicate stage or elevation on the y-axis as well (see the next section). The volume of flow or total amount of water in any given flood is the area under the curve, which means the longer duration floods have more water associated with them.

Floods of longer duration can be more devastating for several reasons. Soils lose their absorption capacity and more water runs off on the ground surface. Levees can become saturated, which increases their potential to fail. In addition, rapid drops in water levels after the river has crested can make levees more susceptible to failure. If the flood occurs during planting, crops can be destroyed if soils remain inundated for long periods of time. Landslides and the subsequent sediment loads to the river become more likely as well.

Figure 6: Flood Duration Hydrographs.



3.1.2 FLOOD TIMING

Over the course of a flood, the flow in a river rises to a peak and then subsides as shown in Figure 6. This peak can be measured in either flow (cfs) or in terms of *stage* (in feet). Generally when flood warning information is provided to the public, it is provided in terms of *stage* or *elevation* that corresponds to the peak that water levels rise at a particular location along the river.

*The **FLOOD STAGE** or **FLOOD ELEVATION** is the depth of water associated with a particular flood measured at a specific location on the river. It can be measured as stage (river depth) or as the ground elevation to which the water rises.*

This peak is also commonly referred to as the river crest (Figure 6). The river crests in the upstream reaches of a river first, and then moves downstream. Faster moving crests tend to have higher velocities causing accelerated bank erosion. The speed that the crest moves downstream depends on a number of factors. The crest on smaller systems, such as the Boulder River or Squire Creek (on the North Fork), tends to translate downstream to the main system more quickly. The greater the difference in elevation at the uppermost point of the river (beginning of the crest) and the outlet point, generally the faster the crest travels downstream. Increasing the availability of flood storage areas, providing additional conveyance channels, or retaining forest or vegetative cover in the headwater regions can slow the rate a crest travels downstream.

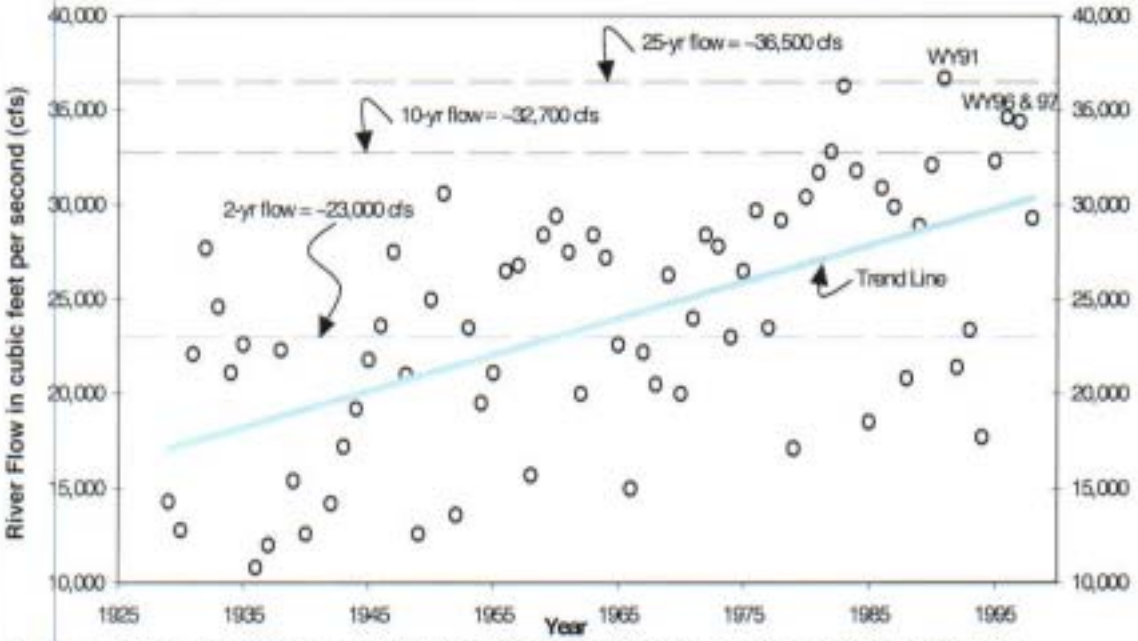
To prepare for floods, it is important to understand how quickly the peak travels from one point to another along the river. Gages on the Stillaguamish River allow emergency management officials to more accurately predict when the flood crest will reach critical areas downstream. Snohomish County's Surface Water Management Division (SWM) analyzed historical flows on the North and South forks and mainstem, using data from active and inactive gages throughout the entire basin. Results showed that the flood crests on each fork most likely converge at Arlington at the same time. This knowledge aids in providing necessary warning to residents on the mainstem.

3.1.3 FLOOD DESIGNATION

Generally, changes in flood events over time are analyzed using the highest flow or peak flow for each year. Gages are placed at select points on rivers to measure the stage at that point. To more accurately assess changes in peak flows, gages should be continuously operated for 30 years or more. In the Stillaguamish River basin, long term flow data have been collected primarily from a USGS gage (#12177000), which is located upstream of Arlington. This gage has been collecting data since the 1930s.

Peak flow data on the North Fork Stillaguamish River are shown in Figure 7. Peaks on the North Fork have rapidly increased since records have been maintained. This increase has been attributed in part to past logging practices in the upper basin (Appendix B), as similar rapids increases on the South Fork have not been observed. As more data are collected or when a river basin is significantly altered in a way that affects the river flow (such as changes in land use or major events like earthquakes), the frequency of flooding must be reevaluated.

Figure 7: Peak Flows on the North Fork Stillaguamish River (Gage #12177000).



The largest flood event in each water year (October 1 to September 30) has been recorded on the North Fork of the Stillaguamish River since 1928. The trend line shows a steady increase in magnitude. (Online Washington NWIS-W Data Retrieval)

Table 2 summarizes the estimated flood frequency magnitudes for the Stillaguamish River extended through 1998. Note that the peaks are slightly different for each fork as well as for the mainstem. Flow on the mainstem is calculated by adding the peaks from the North Fork and South Fork near Arlington because as discussed earlier, it is assumed the peaks arrive at Arlington simultaneously.

Table 2: Stillaguamish River Peak Flows Extended Through 1998.

Recurrence Interval	South Fork near Granite Falls*	South Fork near Arlington*	North Fork near Arlington*	Mainstem at Arlington*
1 in 2-year	16,400	22,000	23,300	45,300
1 in 5-year	21,700	28,400	29,600	58,000
1 in 10-year	25,000	32,400	33,000	65,400
1 in 25-year	28,600	36,700	36,400	73,100
1 in 50-year	31,900	40,700	39,100	79,800
1 in 100-year	34,800	44,200	41,200	85,400
1 in 500-year	41,200	52,000	45,300	97,200

* Flow at Arlington (mainstem) is calculated as the sum of the North Fork and South Fork flows, assuming coincident peaks *(Snohomish County 2000). All flows are provided in cubic feet per second.*

3.2 What is the 100-Year Flood?

Across the Pacific Northwest, rivers rose to record flood levels during November 1990 and 1995, February 1996, and March 1997. In the span of under ten years, the Stillaguamish River experienced five floods between the 25- and 30-year events (Figure 7). The November floods in 1990, which caused significant property damage in the Stillaguamish watershed, were estimated as having a 3 to 4 percent chance of occurring in a given year (also known as a 25- to 30-year flood) on the Stillaguamish River. To some, these floods seemed larger and the designations seem wrong.

The problem lies in the terminology. Although the 25-year flood sounds like it should occur only once every 25 years, it actually has a 4 percent chance that it will occur in any year. Similarly, the 100-year flood has a 1 in 100 probability of occurring or 1 percent chance of being equaled or exceeded in any given year.

The actual number of years between floods of any given size varies. Big floods can happen more than once in a given year or not at all for several years in a row. Climatic conditions, such as El Niño, can change weather patterns, making it possible to have several wet years in a row, which increases the chances of getting significant flooding regularly.

100-Year Flood Facts:

In 30 years (a typical mortgage period) there is a 26 percent chance of a 100-year flood occurring.

There is a 96 percent chance of a 10-year flood occurring in that same 30-year period.

Frequently the elevation of the 100-year flood is less than one foot higher than the elevation of the 10-year flood.

Therefore, damage from the 10-year and 100-year flood are nearly the same, so insuring to federal protection standards makes sense.

3.3 What Causes Flooding?

Flooding is a natural process. It occurs on every river, large and small, in urbanized streams and mountainous creeks. Flooding can result from a shift in the weather patterns, basin topography, channel changes, land use, flow restrictions (dams), or flood control structures (dikes, levees).

3.3.0 THE HYDROLOGIC CYCLE

OROGRAPHIC UPLIFT *is the effect that results when moist air flows inland, reaches a mountain range, such as the Cascades, and begins to rise. As the air reaches higher altitudes, the drop in pressure reduces its ability to hold water, so the moisture falls to the ground as rain or snow.*

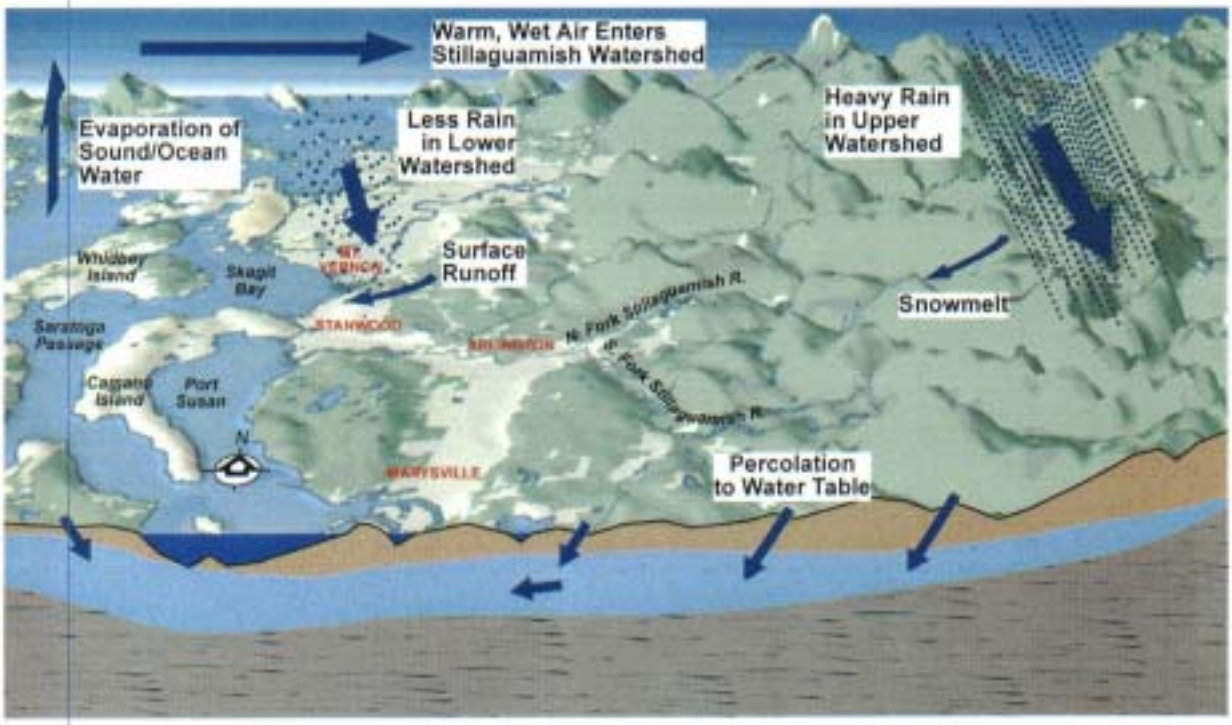
The hydrologic cycle begins with evaporation of water from the oceans. Moving air masses transport the resulting vapor. Precipitation is produced when the air masses are lifted, cooling the air, condensing the moisture and forming clouds. Air masses can be lifted through local heating or as air passes over a mountain range. The latter is called *orographic uplift* and it results in zones of high annual precipitation on the windward side of mountains.

The precipitation that falls on land as rain and snow is dispersed in several ways. A large part is temporarily retained in the soil near where it falls. Heavily forested areas intercept a significant amount of precipitation, which is released back to the atmosphere through *evapotranspiration*.

> ***EVAPOTRANSPIRATION*** *is the combined process of water converting to vapor (evaporation) and via plant tissues (transpiration).*

Evapotranspiration reduces the volume of flows in rivers and streams (Booth and Jackson, 1997) because less water reaches the river system to begin with. A portion of the precipitation finds it way over and through the surface soil to stream channels, while other water infiltrates into the soil to become part of the groundwater. Both groundwater and surface water flow, through gravity, back toward the ocean. Figure 8 is a conceptual graphic of how this cycle works in the Stillaguamish River basin.

Figure 8: Conceptual Hydrologic Cycle in the Stillaguamish River Basin.



3.3.1 TOPOGRAPHY AND CLIMATE

Topography

The Stillaguamish River is wedged between Puget Sound and the Cascade Mountains and draws its flow from the western slopes of the mountains. This area is subject to severe rainfall during warm fall and winter storms. The heavy rain results from orographic uplift in the mountains above the watershed. Over 500 square miles of mostly mountainous

terrain drain to the Stillaguamish River. Within that area, the ground rises from sea level at the river mouth to more than 6,000 feet. The heavy rainfall, the large area feeding into the river, and the steepness of the land add up to the potential for large amounts of floodwater that can quickly reach the flat lands of the river's lower reaches (Figure 8).

Climate

The climate in the study area is typical of the western Washington maritime climate, influenced by the Puget Sound to the west and the Cascade Mountains to the east. An indication of the differences in climate can be observed with the long-term weather gages at the Darrington Ranger Station and in the City of Everett (Figure 9). Everett is south of the Stillaguamish River basin, but the Everett long-term weather station best represents the weather at Stanwood because both Everett and Stanwood are at roughly the same elevation and location relative to the Puget Sound. Stanwood is located in the Stillaguamish River basin's western portion while Darrington is located in the eastern portion.

Facts about the climate and topography in the Stillaguamish River basin.

Of the 684 square miles of lowland and mountain region that drain into the Stillaguamish River, the vast majority (517 square miles, or 76 percent) lies in the mountainous areas upstream of Arlington.

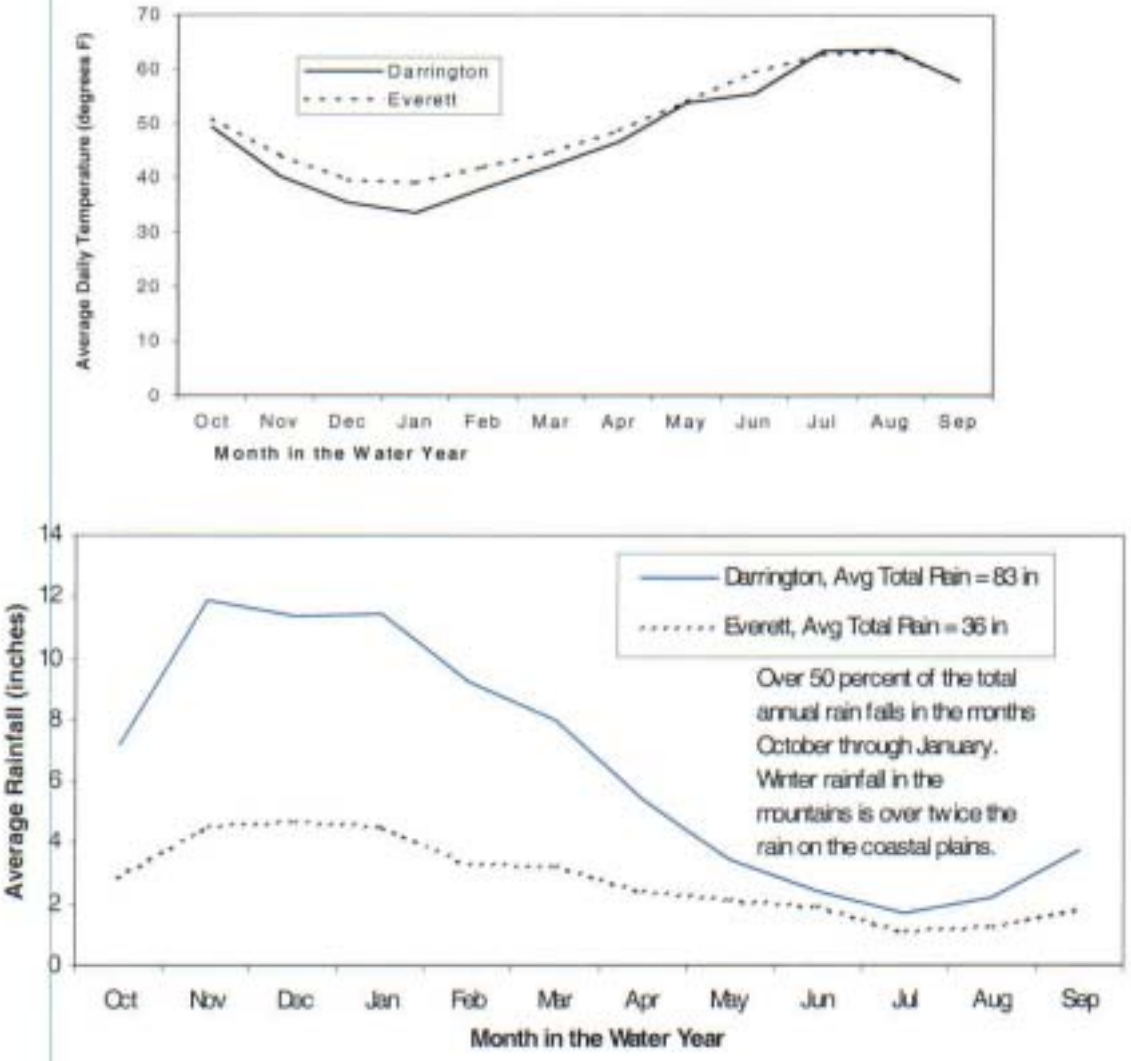
Rainfall is much greater in the mountains. For example, for the early November 1990 flood, up to 9 inches of rain fell in the mountains during a single storm, while only about 1 inch of rain was recorded in Everett. In the second flood later that month, 11 inches of rain fell at Darrington and at the same time, again only 1 inch was recorded at the coast.

The temperature ranges between Darrington and Everett (Stanwood) are similar throughout the year. In winter, the average temperatures at Darrington and Everett (Stanwood) are 36 and 40 degrees F, respectively. The average daily winter minimum is 30 degrees at Darrington and 34 degrees at Everett (similar to Stanwood). In summer, the average daily temperature is 62 degrees at both Darrington and Everett with the average maximum temperature about 72 degrees.

Almost 33 percent of the Stillaguamish River basin contains areas with elevations between 1,000 and 3,000 feet above sea level (STAG 2000). That is important because elevations below 1,000 generally receive precipitation in the form of rain, and elevations above 3,000 generally receive precipitation in the form of snow, but the elevations in between get a mixture of both. This band is known as the rain-on-snow transition areas and this area contributes significantly to the rapid flooding that occurs on the Stillaguamish River (Appendix B).

The most severe flooding generally occurs during the so-called "pineapple express" weather pattern of the fall and winter. When the weather fronts bring warm, wet air sweeping into the watershed, the rainfall can be very heavy. If such rainfall takes place after snow already has accumulated in the mountains, the resulting snowmelt significantly increases the flow of water to the river. The results of the heavy rain on snow are even more severe if preceded by a period of steady rain that leaves the ground in the area too saturated to absorb any more water. Together, these three conditions—accumulated snow, heavy rain, and saturated soil—create the potential for severe flooding along the Stillaguamish River.

Figure 9: Average Temperature and Rainfall at Darrington and Everett.



Precipitation differences between the Everett station and Darrington are significant. Total annual precipitation is 83 inches at Darrington and 36 inches at Everett. Of this, 70 to 80 percent falls between October and March. The average seasonal snowfall is 51 inches at Darrington and 8 inches at Everett. The mountains surrounding Darrington are at a significantly higher elevation. Three Fingers to the south is approximately 6,000 feet above mean sea level. The snowmelt from this mountain and others in the area provides the flow in the Stillaguamish throughout the drier periods of the year.

3.3.2 LAND MANAGEMENT AND FLOODING

The impacts of flooding can also be exacerbated by how land is managed in the basin. Human activities such as forest and agricultural practices, and urbanization can effectively increase the volume of flow and speed up the arrival of the peak flow. Clearcutting large tracts of land, constructing housing developments or industrial areas, constructing roads and highways, establishing infrastructure, eliminating floodwater storage areas (e.g., wetlands) or removing obstacles that slow the flow down (e.g., trees) can all contribute to increasing flood damages.

These practices can add significant volumes of sediment to the river system. Large landslides can cause aggradation, destroy critical spawning grounds and fill in the channel forcing the water to create new flow paths. Managing land use can assist in reducing potential impacts of flooding. Detailed information about these land management practices in each subbasin is provided in Chapter 7.

3.3.3 "CONTROLLING" FLOODS

The devastating floods in Snohomish County in the 1990s were a clear indication that even the highest levee or strongest structure could not contain all the floodwater from every flood in the river's channel. Plugging side channels, straightening rivers, and constructing dikes and levees are methods that have been used to reduce flood damages. In the first half of the 1900s, over $25 billion dollars were spent on flood control efforts throughout the United States. Despite these efforts, flood control costs from 1951 to 1985 were over $62 billion dollars *(The High Risks of Denying Rivers Their Floodplains – New York Times, July 1993, unseen)*.

Flood control structures in any form can temporarily prevent floodplain buildings from being flooded, but dikes, levees, channelization, and other manmade structures designed to restrict or alter flow paths cannot withstand every flood. Overtopping of the structure will eventually occur. Some may even increase flood damages if floodwaters pond behind the structure, increasing the length of time homes are inundated or saturating the flood control structure itself causing it to fail. Channelization or straightening the river increases channel velocities, bank erosion, and may aid in increasing debris loading (trees).

Constructing dikes can give a false sense of security in that homeowners feel protected from floodwaters. This feeling leads to more development, which places more buildings on the floodplain leading to higher flood damages when the flood control structure is eventually overtopped. Effective use of flood storage or conveyance areas aids in reducing flood damages, but it will not eliminate the potential of flooding from occurring. For these reasons, actions that encourage natural floodplain processes were incorporated in this plan to reduce public exposure to risk and prevent continued property damage.

3.4 Geology and Soils

Geologic and soil characteristics within a basin can affect the volume of water reaching the river and sediment inputs to a river. An understanding of the characteristics in the Stillaguamish River basin aids in the understanding of flood patterns.

3.4.0 GEOLOGY

Puget Sound regional topography and geologic formations were shaped predominantly by cycles of glacial ice encroachment and recession during the middle to late Pleistocene period, which occurred over 3 million years ago. The area known as the Puget Lowlands were formed from more recent glacial deposits derived from several regional glaciations; the most recent, called the Vashon glaciation, occurred from 15,000 to 13,500 years ago and at its maximum is estimated to have been 4,000 feet thick near Seattle. As the glacier advanced, valleys were deepened, forming the Puget Lowlands.

SOIL TEXTURE —

Soils are defined based on the relative proportions of sand, silt, and clay in a unit. In increasing proportions of fine particles, soil classes are:

decreasing permeability ↓

sand
loamy sand
sandy loam
loam
silt loam
silt
sandy clay loam
clay loam
silty clay loam
sandy clay
silty clay
clay

These can be further refined with 'coarse,' 'fine,' or 'gravelly.'

Each time the glacier advanced, a lake formed in the lowlands as the Strait of Juan de Fuca became blocked by ice. On the bottom of this glacial lake, finely ground remains of rocks pulverized by glacier action settled out. These deposits became the clays of the lowlands. As the glacier advanced, its weight compacted the underlying sediments and created a concrete-like material known as Vashon till (or, locally, hardpan) beneath it.

Vashon till is a dense, partially cemented, poorly sorted, nonstratified silty sand to sandy silt with gravel, cobbles, and boulders. The percentage of silt in Vashon Till, which covers most of the County's upland areas, typically varies from 10 to 30 percent. As the glacier retreated, water from the melting ice deposited thick layers of sand and gravel called outwash. When the strait reopened, seawater flooded the deeper lowlands to form what is now Puget Sound. Post-glacial processes, including weathering, erosion, and sedimentation, are ongoing in the surface soils. Alterations and activities by people also influence the existing geologic processes.

3.4.1 SOILS

What the underlying geology of the basin means to flooding is based on how easily water can travel through the soil. If water can't infiltrate through the topsoil quickly, flood damages can be increased. For example, sands and gravels generally allow for rapid infiltration of runoff, but rates are very low through *glacial till*. It is very common for water to infiltrate the top surface and 'perch' on the underlying *hardpan*, flow laterally, and resurface as springs in hills or creek banks.

As shown in the U.S. Soil Conservation Service Soil Survey for Snohomish County (SCS 1983), the soils of the Stillaguamish River basin vary depending on the location (Figure 10). At the mouth of the river at Port Susan and along the river banks, the soils are silty clay loams. These fine-grained soils are typically deep, poorly drained, and formed from *alluvium* with low slopes and low erosion potential.

The wide river valleys and *terraces* are typically gravelly loams and sandy loam formed from *glacial outwash* and volcanic ash. These moderately deep soils are typically well draining with low erosion potential.

ALLUVIUM *— Material, such as sand, silt, or clay, deposited on land by rivers and streams.*

GLACIAL OUTWASH *— Gravel, sand, and silt, commonly stratified, deposited by glacial melt water.*

GLACIAL TILL *— Unsorted, nonstratified rock material transported and compacted by glacial ice.*

HARDPAN *—A hardened or cemented soil horizon, basically impermeable.*

PERMEABILITY *— Measure of water's ability to move through soil.*

TERRACE *— An old alluvial plain, ordinarily flat or undulating, bordering a river. lake or sea.*

The foothills of the Cascade Mountains are made up of gravelly loams. These moderately deep soils are formed from glacial till and volcanic ash with an underlying layer of *hardpan* that reduces *permeability*. In the steeper slopes these soils can be subject to erosion.

The mountainsides are predominantly a mix of silt and gravelly loams, which have moderate permeability. The fine grains of these soils, coupled with their location on steep slopes, make them subject to erosion. The mountain gravelly loam soils consist of glacial till, volcanic ash, and weathered volcanic material (lava). Gravelly loams have a high erosion hazard and are subject to seasonal saturation.

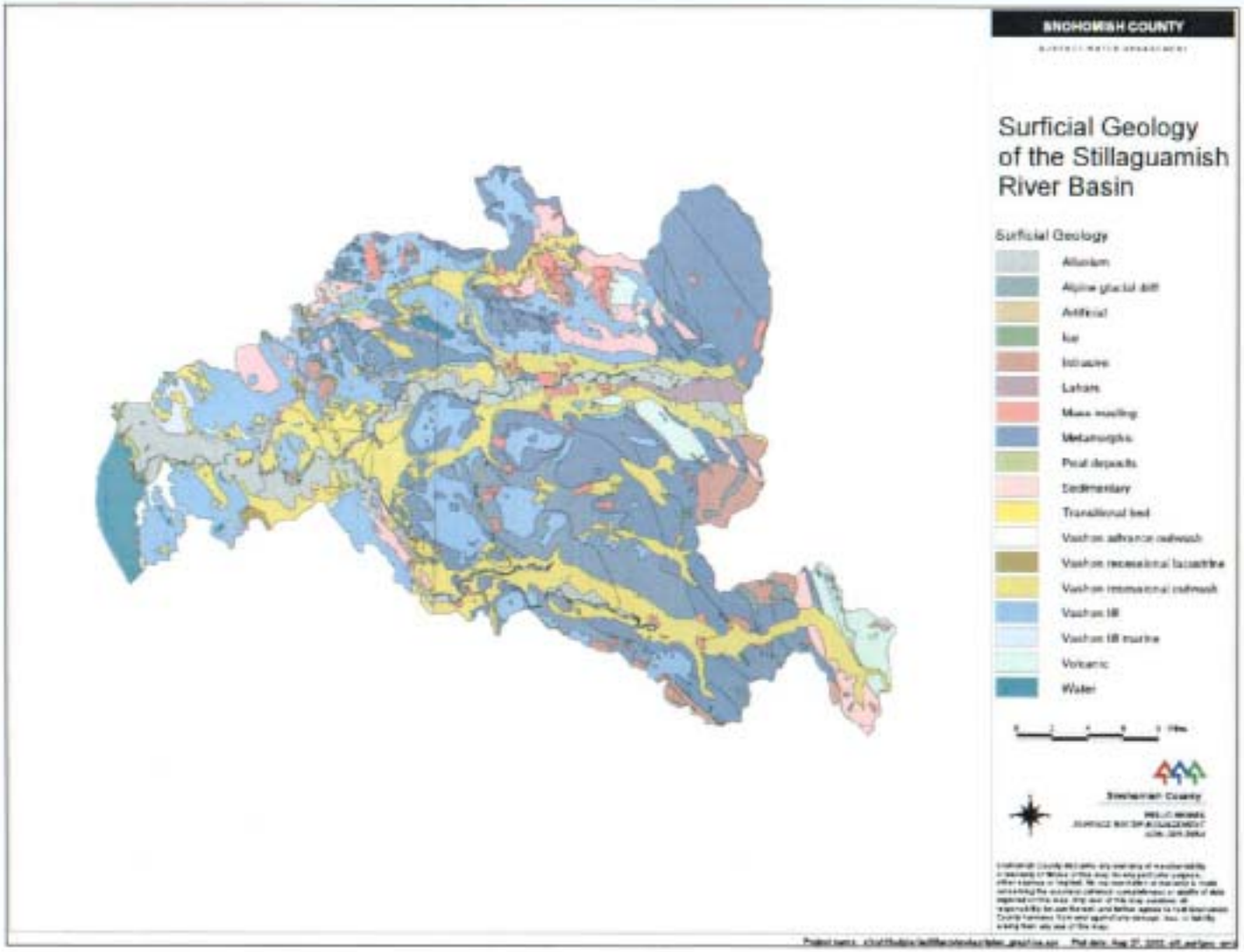
3.4.2 THE ROLE OF SEDIMENT

A complicated relationship exists between sediment in rivers and the potential for flooding. The sands and gravels that dominate the Stillaguamish River channel and floodplain pose a flooding hazard when there is too much of it for the river to transport and it begins to accumulate in the channel. The Stillaguamish River is particularly susceptible to sediment inputs in its upper reaches. The two forks begin their descent to the main river's valley in steep, unstable mountainous areas that are highly prone to landslides because of steep slopes, soils, and land management practices (Appendix B).

Channel Shaping

The flowing water of the river has only limited energy to carry sediment along with it. That means some of the sediment soon settles to the bottom where it begins to accumulate. How much sediment the river can carry depends on how fast the water is flowing, which in turn is influenced by the slope and width of the river channel. It also depends on the amount of flow and on the size of the sediment granules.

Figure 10: Surficial Geology of the Stillaguamish River basin.



River channels transport sediment as bedload, suspended load, or dissolved load. Although the finer sediment (i.e., suspended and dissolved) is harmful to fish, the coarser material, or bedload, that is transported along the bed of the river plays the most significant role in shaping and forming the channel and floodwater behavior (Inter-fluve 2000).

The North and South forks contain reaches that either transport or deposit bedload material. The steeper, narrower reaches above Deer Creek on the North Fork or above Robe Valley on the South Fork generally behave as transport reaches for sediment. The slope becomes gentler downstream of Deer Creek on the North Fork and near Granite Falls on the South Fork, which sharply diminishes the river's sediment-carrying capacity resulting in sediment deposition. The finer sediment is transported downstream where it is deposited on the flatter alluvial floodplain on the mainstem. Large flood events eventually transport these depositions out to Port Susan or Skagit Bay. Approximately 83% of the annual sediment transport occurs during the months of November through February when the Stillaguamish River experiences its highest flow, with most sediment transport occurring in November (Collins 1997).

Sediment Sources

Several major landslides in the Stillaguamish River watershed have contributed significant amounts of sediment to the system with almost 97 percent of the slides taking place in the North and South fork subbasins. Almost 75 percent of the slides were associated with forest practices (22 percent were attributed to roads and 52 percent to clear cuts). DeForest Slide above Deer Creek, Higgins Ridge on the North Fork, and the Gold Basin and Canyon Creek slides on the South Fork are the most noted landslides in the basin (Collins 1997).

Bedload material has been documented (Pess and Benda 1994, Collins 1994) as passing through the Stillaguamish River system in waves over a ten-year period. These waves change the channel through aggradation and degradation. The mainstem of the Stillaguamish River acts as a sink for this material, which has resulted in significant channel aggradation in the Upper Stillaguamish and the Old Stillaguamish River. As a result of this aggradation, a majority of the flow passes through Cook Slough and Hatt Slough to Port Susan.

3.4.3 VOLCANOES

The Cascade Range extends for more than 1,000 miles from southern British Columbia to northern California and includes thirteen active volcanic peaks. The Stillaguamish River basin has been affected by volcanic events at Glacier Peak in the Cascade Range.

***LAHARS** are slurries of volcanic rock, sediment, and ash mixed with water that rush down streams and river valleys leading away from a volcano.*

Glacier Peak is located on the Stillaguamish River basin's eastern boundary and has erupted at least twelve times since the end of the last glacial event, which was approximately 14,000 years ago. Historically, the mountain has experienced larger and more violent eruptions than any other Cascade peak except for Mount St.

Helens. Twelve thousand years ago, an eruption larger than the 1980 event at Mount St. Helens determined the Stillaguamish River's present course.

Prior to the eruption, the Sauk River flowed into the upper North Fork of the Stillaguamish. However, *lahars* created during the eruption buried and then damned the upper portion of the North Fork river valley at Darrington. Lahar deposits at Darrington have been found to be several hundred feet thick. As a result of these lahars, the Sauk and Suiattle Rivers were diverted and now flow north into the Skagit River.

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Chapter 4

Flood Warning and Operations in the Stillaguamish River Basin

CHAPTER 4 - FLOOD WARNING AND OPERATIONS IN THE STILLAGUAMISH RIVER BASIN

4.0 Introduction

Although Stillaguamish River floods can happen at any time, they are most common from November to February. Snohomish County has developed a flood warning system to prepare for and respond to flood events. The program is designed to warn residents and agencies of an impending flood so that they can make preparations before flooding occurs. The flood warning system involves river forecasting conducted by the National Weather Service (NWS) and local river monitoring conducted by Snohomish County Department of Public Works Surface Water Management Division (SWM). When a flood occurs, a coordinated response effort involving multiple jurisdictions and agencies is carried out at Snohomish County's Department of Emergency Management's (DEM) Emergency Operations Center (EOC). This chapter describes the current flood warning system and how it operates in the Stillaguamish River. Improvements to the flood warning system are discussed in Chapter 7 of this document.

4.1 The Mechanics of Flood Warning

4.1.0 WEATHER

The NWS is the agency responsible for issuing warnings about potential floods. The information used to develop flood warnings is gathered using data collected from the United States Geological Survey (USGS) telemetric gage network and from regional weather conditions and patterns. These data are integrated into a hydrologic computer model at the NWS's River Forecast Center in Portland, Oregon. Rainfall reports, soil saturation information, snow depth information, and temperature readings may also be included as variables in the computer model. Depending on the results of the model and the severity of weather conditions, the NWS issues a *flood watch, flood warning, or flood statement.* The NWS also issues river forecasts, which may resemble warning statements or contain detailed stage information, such as the predicted time a river will crest.

When a ***Flood Watch*** is issued, flooding is possible in a specific area within 12-36 hours, but its occurrence, location, and/or timing is uncertain. Flood watches are issued for a specific County, not for specific rivers.

*A **Flood Warning*** is issued on specific rivers and indicates that flooding is imminent in 12 hours.

*A **Flood Statement*** is issued once a flood has occurred and is updated every six hours.

As knowledge about weather patterns and conditions has developed, the probability of accurately predicting a flood has increased. Recent studies of El Nino and global

atmospheric circulation patterns have given weather researchers the ability to identify large-scale weather features that typically lead to flooding (such as rain-on-snow events). Thus, early recognition of threatening weather patterns on a regional scale, combined with statistical data collected from river gages, provides a relatively long lead-time to prepare for a flood event.

Local conditions, however, vary greatly and may not always be included in the NWS's hydrologic models. As a result, Snohomish County conducts its own river monitoring before and during a flood event to supplement NWS's flood statements with information about local conditions that may affect flooding.

4.1.1 GAGES

SWM uses gages placed on the major rivers, including the Stillaguamish, in the County to monitor river flow and stage. These gages, which were installed by either SWM or USGS, are available for use in flood fight operations and flood monitoring.

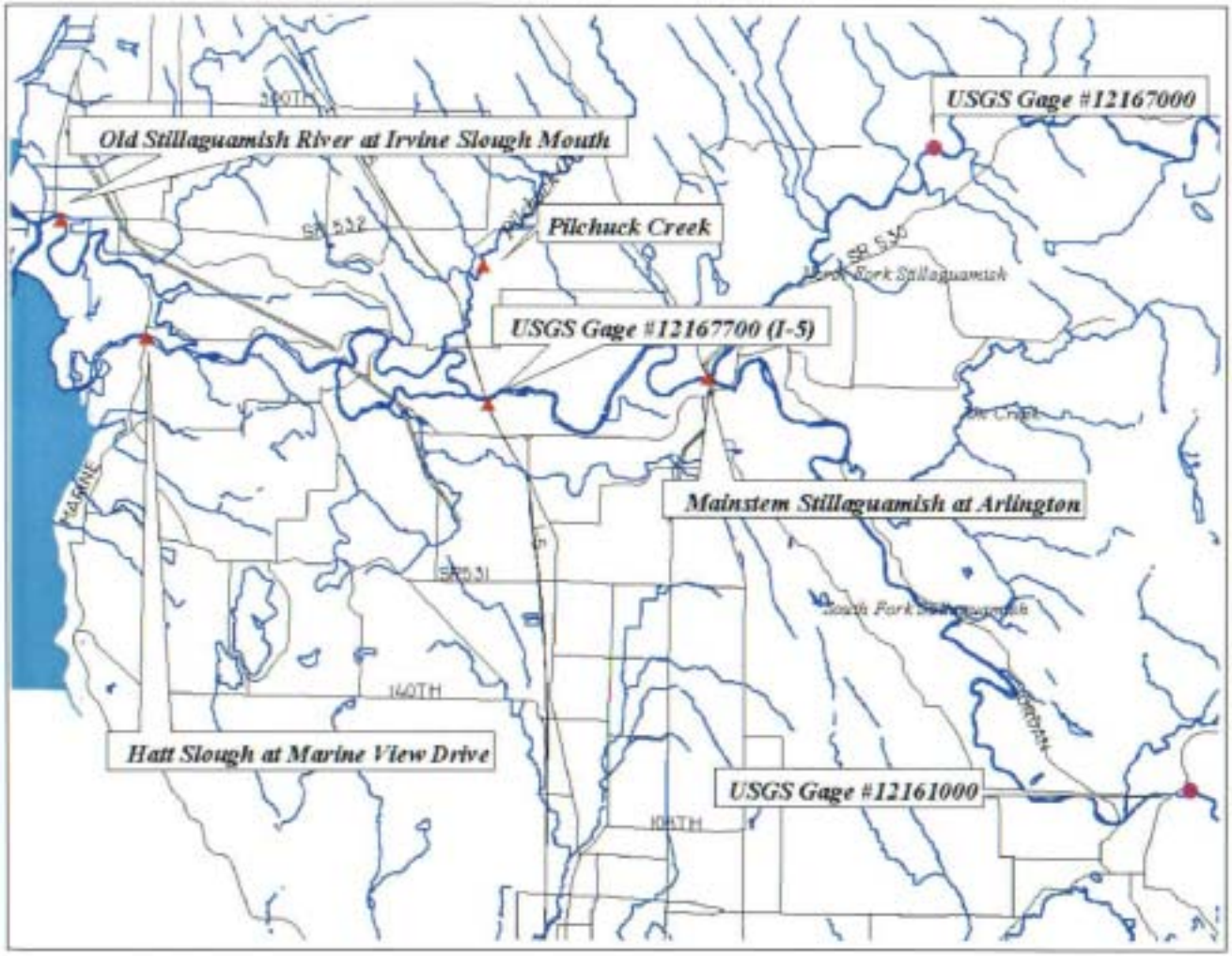
Data Collection

Two types of river gages are used to monitor rivers. They include automated and manual gages. Automated gages employ telemetric or radio transmissions to measure specific conditions in the river. These transmissions are sent to a computer center based in SWM. Manual gages, or staff gages, are large wooden rulers, graduated in feet and tenths, which are observed manually for water level. Figure 11 indicates the location of active gages on the Stillaguamish River. Two USGS gages include #12167000 on the North Fork and #12161000 on the South Fork. An additional active County gage (not shown) in the upper North Fork watershed on Whitman Bridge has been active since August 1998. County staff will be installing telemetered gage at I-5 in 2002 to supplement the data obtained from the existing Ecology-maintained gage (#12167700).

Private residents in the DEM's River Watch Program monitor staff gages in the field. Although staff gages are useful when multiple readings are reported from one site, automated gages are more efficient because they provide real time data that may be needed on a regular basis during a flood event.

Automated gages are normally placed far enough upriver so that the time of the expected crest reaching downstream areas can be predicted. For example, residents in the Silvana area, on the mainstem Stillaguamish River, are given approximately four to six hours of advanced warning because of the location of the automated gages on the North Fork of the Stillaguamish at Cicero Bridge and South Fork of the Stillaguamish near Granite Falls.

Figure 11: Locations of Gages on the Stillaguamish River.



4.2 Planning

Prior to flood season, staff from SWM, Public Work Roads, Maintenance, and Public Involvement and Environmental (PI/E), Planning and Development Services (PDS), and the DEM, and the Corps hold meetings to discuss locations along Snohomish County's major rivers that are expected to be particularly vulnerable to flooding in the upcoming season. The meetings also provide a chance for these agencies to review the response procedure and coordination process that is implemented during a flood event at the EOC.

In addition to these meetings, County staff conducts site visits to obtain pre-flood information on each site and to determine what emergency actions to take should they be required. In addition, PI/E staff take pictures of these sites prior to the flood to assist in post-flood repairs should it be required. These areas are monitored closely during a flood if they are accessible, but most assessments are conducted following the flood event because of safety issues.

Because floods cross jurisdictional boundaries, the EOC serves as the central location to coordinate flood operations during an event in unincorporated Snohomish County and communities in north and east county.

4.2.0 WHO'S WHO IN FLOOD PLANNING

Many actions happen simultaneously during a flood event. Public Works staff and EOC volunteers monitor rivers, check NWS forecasts, and maintain contact with the NWS meteorologist who provides forecasts for the situation. River analysis charts and tides are plotted, while the DEM flood warning network is updated. Snohomish County's SWM and Road Maintenance Divisions dispatch field crews to respond to requests for assistance received through phone banks. Field Command Posts (CPs) may be mobilized to allow agencies to handle situations in the field that require immediate attention. The representatives from the interagency team at the EOC are in contact with the CPs to further coordinate the flood fight.

The agencies participating in the interagency team have a specific role at the EOC. The following is a brief explanation of each agency's role, as described in DEM's Flood Operations Manual (2000).

DEM/EOC

The DEM is responsible for establishing a centralized system for coordinating flood operations in Snohomish County. The director leads the EOC volunteers and coordinates all interagency activities. The EOC volunteers are responsible for operations, analysis and planning of incoming river data, public information, communications, logistics, and administration. The DEM has a flood warning network that is continually updated. The flood warning network is part of a public information system that provides information to the public through news releases, local radio frequencies, or direct telephone contact.

Snohomish County Executive Office

The County Executive authorizes the Declaration of Emergency and is the final decision making authority in a flood fight.

Snohomish County Department of Public Works

The County Engineer has been designated the Flood Coordinator for the unincorporated areas of the County and as such is responsible for the overall direction and control of the flood fight operations for the County. The Flood Coordinator also is the contact between the County Executive and the director of the DEM. A Declaration of Emergency is prepared by the County Engineer, which is reviewed and approved by the County Executive. The County Engineer has the authority to request and to direct assistance from the Corps, National Guard, other armed forces organizations, and/or public agencies. Road Maintenance and SWM provide phone banks to receive and respond to public requests for assistance for the duration of the flood.

Snohomish County Sheriff's Department

The Sheriff's department provides traffic management, assists with dissemination of warning and evacuation, coordinates search and rescue, provides security for evacuated areas, and assists with the collection of field intelligence.

Fire Districts/Emergency Medical Services

The districts and services provide emergency medical aid, and assist with dissemination of warnings, evacuation, and suppression of fire. They also assist with the direction and control of any sandbagging operations in incorporated areas and other areas not under supervision of the County Engineer.

Snohomish County Chapter-Red Cross

The Red Cross provides human services assistance to flood victims (food, clothing, temporary shelter, recovery funds, etc.), mass feeding for volunteers and other personnel involved in the flood fight, assesses the human services needs of the community, and coordinates local application of human services program.

U.S. Army Corps of Engineers

The Corps provides field intelligence, carries out federal flood fight operations, provides technical advice and support, and contracts for private sector equipment and resources. Once a river reaches flood stage, the Corps can authorize emergency funds to be used in the event of a dike breach or other unanticipated emergency.

4.2.1 FLOOD OPERATIONS PHASES AT THE EOC

As described in Chapter 2, stage is the primary standard of measurement used in flood monitoring. It determines the level or extent of agency response during a flood. On the Stillaguamish, the stage at Arlington is used to coordinate interagency response efforts.

The EOC activation process begins when the NWS issues a flood watch for the County. DEM has identified four Flood Operations Phases. Specific actions, which are listed below, are taken at each phase (DEM 2001).

When the Stillaguamish River floods, the water flow generally follows predictable patterns. The corresponding conditions that occur at each phase are provided. Generally, flows on the forks stay confined to the main channel except during larger events (usually Phase III).

> ***Flood stage*** is the elevation of water in a river at which overflow of the natural banks begins to cause damage, or begins to present a potential flood-damage hazard along the reach in which the measurement is made.

Phase I

The DEM staff duty officer opens the EOC and notifies EOC staff and volunteers of the situation, but they are not yet required to report to the center. Although SWM and Road Maintenance Divisions are in contact and monitoring the situation, they are also notified by DEM if there is any indication that the County's rivers are predicted to reach or exceed *flood stage*.

Stillaguamish River Level: 12 feet at Arlington
12+ feet at North Fork-Cicero Bridge (Gage 12167000)
12+ feet at South Fork-Granite Falls (Gage 12161000)

At this phase, most flow remains confined to the channel. Phase I and Phase II (below) official flood stages have been lowered because the river was overtopping SR532 near Silvana at this lower stage.

Phase II

> ***Overbank flood stage*** is when the rivers have reached the banks of the river and begin to flow into floodplain areas.

Overbank flood stage occurs and the EOC is partially activated. All members of the EOC staff are mobilized and volunteer section leaders must report to the EOC. Additional volunteer presence may be requested. The County Executive, the Public Works Department, and the Sheriff's office are advised. Floodplain municipalities are alerted and field observations are begun. A public information system is set up, and telephone operators are in place to offer assistance to the public. Washington State's Emergency Management Division is notified that the EOC has been activated.

Stillaguamish River Level: 14 feet at Arlington
12+ feet at North Fork-Cicero Bridge
12+ feet at South Fork-Granite Falls

When the river reaches the level prompting Phase II response, Norman Road and Marine Drive are closed due to overtopping and water begins to approach SR530 east of Silvana.

Phase III

Phase III is triggered by a significant flood event and the EOC is fully activated. The EOC staff size is strengthened to meet increased telephone call volume. Field operations and reconnaissance teams are increased. All supporting agencies and key personnel are alerted and advised. Agencies are notified about road closures, diking/drainage district problems, slides, etc. Contact with the Corps' Snohomish County flood team is established, if it has not already been done. By Phase III, all relevant agencies should be notified that the County EOC has been fully activated and their representatives are asked to attend.

Stillaguamish River Level: 17 feet at Arlington
12+ feet at North Fork-Cicero Bridge
12+ feet at South Fork-Granite Falls

Floods larger than 7- to 10-year event can cause the levee on the right bank of the river downstream of Oso to overtop. Usually this overtopping occurs during Phase III. This overtopping may impact SR530 if significant volumes overtop the levee as flows follow abandoned channels towards the road. SR530 has also experienced water over the roadway near Cicero Park. Two bridges (old Whitehorse Trail bridge and SR530 bridge) act as pinch points on the river and cause the river to stack up behind the bridge system. This stacking of water causes flood flows to backwater into Cicero Park on the right bank directing the flow towards SR530.

Phase IV

Phase IV is invoked when a major flood event has occurred and significant damage can be expected. Overtopping of most dikes will occur, road closures will be widespread and can be expected to restrict transportation activities in the County. The Corps' Snohomish County Flood Team should be on site. Assistance may need to be requested from the Washington National Guard via Washington State Emergency Management Division and Federal Emergency Management Agency (FEMA 1996) should be notified that the flood response may exceed the capabilities of the County. Problems are documented in anticipation of potential cost and recovery efforts.

Stillaguamish River Level: 18+ feet at Arlington
12+ feet at North Fork-Cicero Bridge
12+ feet at South Fork-Granite Falls

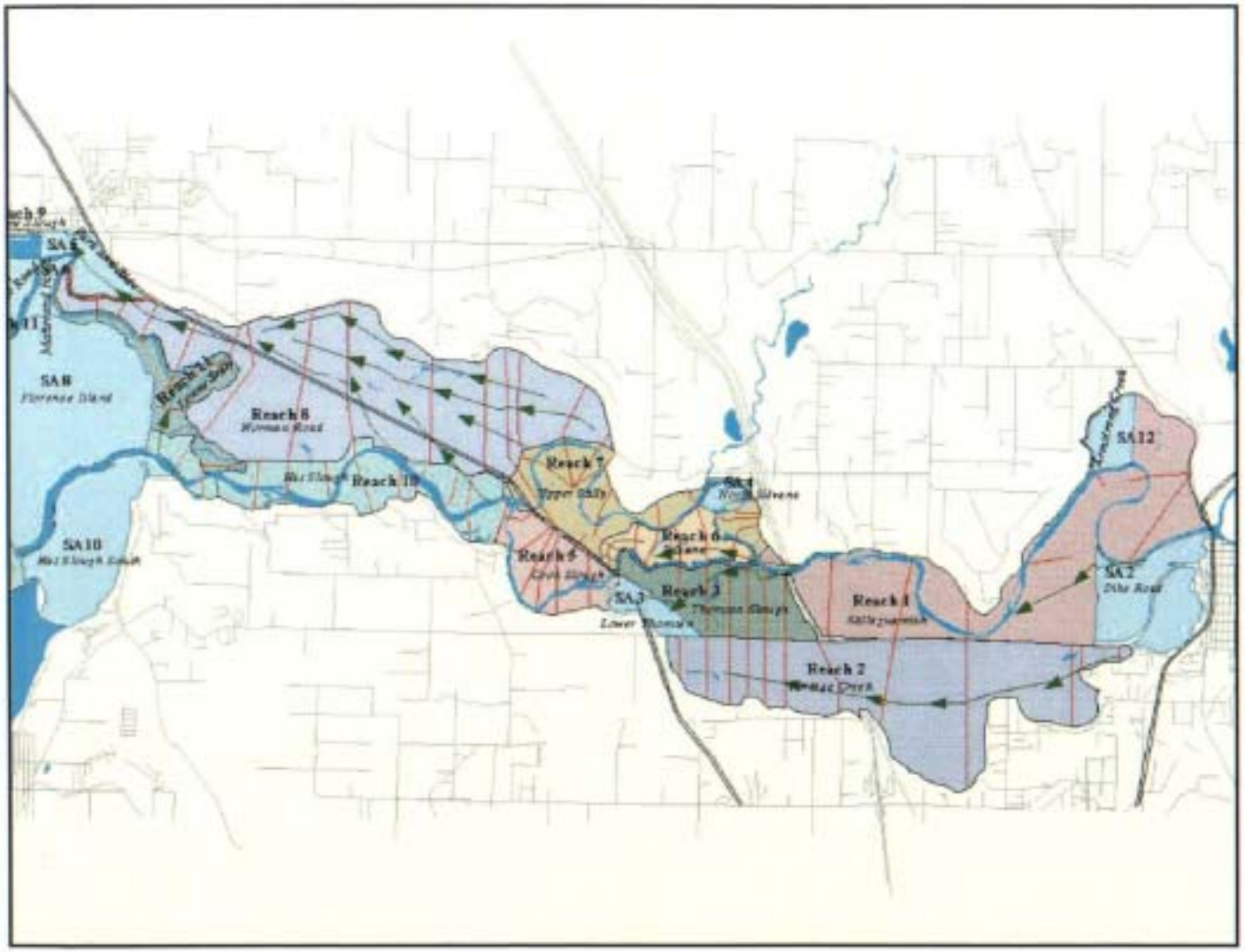
Phase IV begins when the Arlington gage indicates the river level is at 18 or more feet. This size of event corresponds to a major event on the Stillaguamish. As indicated above, significant damage and flooding would be expected. On the North Fork, water overtops SR530 near Mile Post 29, leaving only McGovern Road as an alternative route for traffic.

Once water reaches the mainstem, the entire floodplain is susceptible to inundation. As shown in Figure 12, flood flows in the upper reaches of the mainstem enter abandoned sloughs (e.g., Thomsen Slough) and backwater into smaller creeks (e.g., Armstrong or Portage creeks). Depending on the size of the flood, overtopping of Dike Road Dike near the confluence is possible (as in the 25- to 30-year floods of 1990).

Once the river passes under the I-5 corridor, the flow splits to Upper Stillaguamish channel and south through Cook (Koch) Slough. Flow from Pilchuck Creek joins the Upper Stillaguamish channel and flow from Portage Creek joins Cook Slough. Water overtops the right bank (looking downstream) of the Upper Stillaguamish channel and flows along the bank of Pioneer Road and the Burlington Northern Railroad (BNRR). A natural swale or high flow channel exists, which directs flow downstream towards the Stanwood lagoons. During Phase IV, roads south of Stanwood are closed.

The flow from Cook Slough and additional flow from Portage Creek continues towards Port Susan through Hatt Slough. Some flow from this channel enters the Old Stillaguamish River channel to flow towards Stanwood, but the significant threat of flooding to Stanwood is a result of the flow that overtops the Upper Stillaguamish River channel banks several miles upstream. Floodwaters trapped on the wrong side of the levees near Stanwood stack up against the lagoons. The levees along the lagoons are higher than those along the river, which allows water to overtop the river levees first and flow back into the Old Stillaguamish River channel. Some of this flow crosses over to Florence Island as well.

Figure 12: Flood Patterns on the Mainstem Stillaguamish River.



4.3 New Flood Fighting Techniques

The Stillaguamish Flood Control District recently developed an easier, quicker way to plug dike breaches against floodwater than the time-tested method of filling and stacking sandbags. Interlocking vinyl sheets, commonly used in bulkhead construction are being used as a replacement (Figure 13). The advantage of the panels is they are relatively easy to assemble; 50 linear feet of emergency barrier can be assembled in less than an hour with five or six people. The panels can be used repeatedly over several years. The cost is approximately 6 dollars per foot. Sandbags cost approximately 40 cents each and can be used only once.

Figure 13: New Flood Fighting Technique Using Interlocking Panels.

4.4 Who Can I Contact For More Information?

Snohomish County's flood warning system involves cooperation and communication between many agencies. Because floods affect multiple jurisdictions, interagency coordination is essential for an efficient and effective flood fight. The EOC provides the location and framework for a coordinated response needed in unincorporated Snohomish County, including areas most affected by flooding on the Stillaguamish River. Table 3 provides a list of resources for residents who are impacted by flooding in Snohomish County. Please check the DEM for the most current information.

Table 3: Flood Information Sources.

Flood Information Sources	***Phone Number or Radio Frequency***
Emergencies	Call 911
Flood Information for Stillaguamish	425-388-3653
National Oceanographic and Atmospheric Association (NOAA) Weather Radio	162.550 MHz
Broadcast Media	KIRO Radio 710 AM or 100.7 FM
Snohomish County Amateur Radio Service	Listen to 146.32/92 for instructions on the correct flood information channel
Citizens Band Radio	Listen to Channel 9 for instructions on the correct flood information channel
DEM non-emergencies; Road conditions and closures	425-423-7635
Surface Water Management Wall Street Phone Bank-Requests for Assistance	425-388-6467
Road Maintenance Phone Bank	360-862-7500

The USGS and the Northwest River Forecast Center (NWRFC) maintain two online sites. Stream flows and other flood information can be obtained from USGS site at www.usgs.com. Flood watches, warnings, and statements in addition to forecast information can be obtained from NWRFC at www.nwrfc.noaa.gov.

4.2 References

Federal Emergency Management Agency Emergency Management Institute. August 1996. Flood Fight Operations. Quark Management Service, Wisconsin.

Snohomish County Department of Emergency Management. August 2001. DEM Suggested Operating Guidelines, #1 & #19.

Snohomish County Department of Emergency Management. November 2000. Flood Operations Manual.

Web Sites Referenced

United States Geological Survey (USGS) www.usgs.com. For information about stream flows.

Northwest River Forecast Center (NWRFC). www.nwrfc.noaa.gov. For information related to flood watches, warnings, and statements in addition to forecast information.

CHAPTER 5

FLOOD HISTORY

CHAPTER 5 - FLOOD HISTORY

5.0 Introduction

Documentation of flooding on the Stillaguamish dates back to the latter part of the 19th century when pioneers first settled the area. This chapter explains the major historic flood events along the mainstem of the Stillaguamish River, which is where most documentation is available. Although an effort was made to keep the description of each flood event consistent (e.g., peak flow, structural damage, or dike/levee failures), this information was not always available in the research material.

As described in the Chapter 2, general flood characteristics (peak flow, crest elevation, duration of flood, etc.) in the Stillaguamish River depend on a number of factors, such as rainfall, antecedent ground moisture conditions, snowpack, temperature, and tides. High tidal elevations create backwater effects in the lower reaches of the river, which when combined with high flood flows, can significantly increase the flood levels in the lower mainstem. Flood flows in the Stillaguamish can last for several days, however crests are generally maintained for only a few hours (FEMA 1983).

5.1 Stillaguamish River – Major Historic Floods

5.1.0 MAIN STEM MAJOR FLOOD EVENTS: 1860-1930

Between 1860 and 1930, when the area was first settled by pioneers and developed, high watermarks served as the only available flood records, and flood damages were considered to be fairly minor due to the sparse population. Gages to continuously measure flows in the Stillaguamish River, which provide a more accurate method of comparing floods, were not installed until the late 1920s.

The earliest known account of flooding in the Stillaguamish River basin is given in a report on the navigability of the river in Senate Document No. 39, Forty-Sixth Congress, Third Session, written in 1880. This report states that because the banks of the river were relatively low, they were subject to frequent overflows. This problem was considered minor compared to the need to improve navigability to support the growing logging industry.

Despite a lack of recorded flow rates, an early Corps' report (1930) listed the floods known to have taken place in the Stillaguamish River prior to 1930, including the floods of 1884, 1897, 1909, 1911, 1913, 1917, 1921, and 1924. Stanwood historian G. B. Joergenson also described the floods of 1879, 1880, 1887, 1897, 1909, 1911, 1917, and 1921 in a document he compiled during in the 1940s (Stanwood Area Historical Society 1991) (Table 4).

Table 4: Historical Flood Events on the Mainstem Stillaguamish River.

Dates of Flood Events				
1879	1911	Jan 1935	Nov 1958	Nov 10, 1990
1880	1913	Oct 1945	Nov 1959	Nov 24, 1990
1884	Dec 1917	Oct 1947	Dec 1959	Nov 8, 1995
1887	Dec 1921	Dec 1949	Feb 1960	Nov 29, 1995
1893	1924	Feb 1951	Nov 1962	Feb 8, 1996
Nov 1896	Feb 1932	Oct 1955	Dec 1975	Mar 19, 1997
Nov 1897	Nov 1932	Nov 1955	Dec 1977	
Nov 1906	Dec 1932	Dec 1956	Dec 1979	
Nov 1909	Dec 1933	Dec 1957	Dec 1982	
Dates collected from a variety of sources including Corps 1930, Corps 1963, and Stanwood Historical Society 1991.				

According to the Corps' report (1930), the floods with the highest watermarks in the Stillaguamish during this period occurred in 1897 and 1911, though no measurable damage was recorded during these two events. This information was confirmed by G. B. Joergenson (Stanwood Area Historical Society 1991), who described the floods of 1880 and 1897 as reaching flood levels at least three feet higher in Stanwood than any previous floods, and the flood of 1911 as being much higher than the long-duration flood of 1909. Another account of these early floods (Essex 1982) describes the flood of 1887 as breaching dikes along the Stillaguamish and causing floodwaters to reach a depth of roughly three feet in some locations at Stanwood. The only flood known to have caused significant damage in the lower floodplain was the 1921 flood. This flood, though it had a lower crest elevation than other floods, inundated the adjacent floodplain for a much longer period, a total of six days, and is generally regarded as the most significant flood of this period.

Table 5: Largest Peak Floods on the Mainstem Stillaguamish River from 1930s to Present.

Date of Flood	*Estimated Peak at Arlington (cfs)*	*Date of Flood*	*Estimated Peak at Arlington (cfs)*
Feb 27, 1932	65,000	Dec 15, 1959	54,800
Nov 24, 1990	64,700	Nov 29, 1995	53,000
Feb 10, 1951	61,000	Feb 1960	53,000
Nov 10, 1990	60,700	Mar 19, 1997	51,000
Nov 23, 1959	59,600	Nov 1955	50,500
Nov 1958	58,500	Feb 8, 1996	>50,000
Dec 7, 1977	57,000	Nov 1962	50,000
Nov 1932	56,000	Nov 1955	50,000
Dec 1956	55,000	Oct 1945	50,000
Jan 1935	55,000	Dec 3, 1975	46,500
		Dec 1979	Magnitude Unknown

Flood damage was limited during this early period for several reasons. As the principal industry in the flooded region shifted from logging to dairy farming, livestock were simply moved to high ground until the flood receded. Inundation rarely lasted more than two or three days, not long enough to kill the grass on the dairy farms. Farm crops were generally unaffected since most floods did not occur during the growing season. In fact, some farmers regarded the deposition of silt on their land as favorable. Merchants in the area, however, lost considerable trade during some of the later floods due to flooded highways interrupting

transportation. Structural damage to highways and railways during the 1921 flood was estimated to be nearly $400,000 (1930 dollars) (Corps 1930).

5.1.1 MAJOR FLOOD EVENTS: 1930-PRESENT

With the installation of USGS flow gages in both forks of the Stillaguamish River in 1928 and 1929, the peak discharge rates in the river were recorded, providing a better means of comparing flood events. Peaks from this gage were summed with those on the South Fork to estimate flows on the mainstem. Note in Table 5 that each of the historical peak flows during the past 46 years is less than the 50-year peak flow for the Stillaguamish River, estimated by the County's estimated peak flood magnitude of almost 80,000 cfs. By definition, the 50-year peak flow occurs an average of once every 50 years or has a 2 percent chance of happening in any given year.

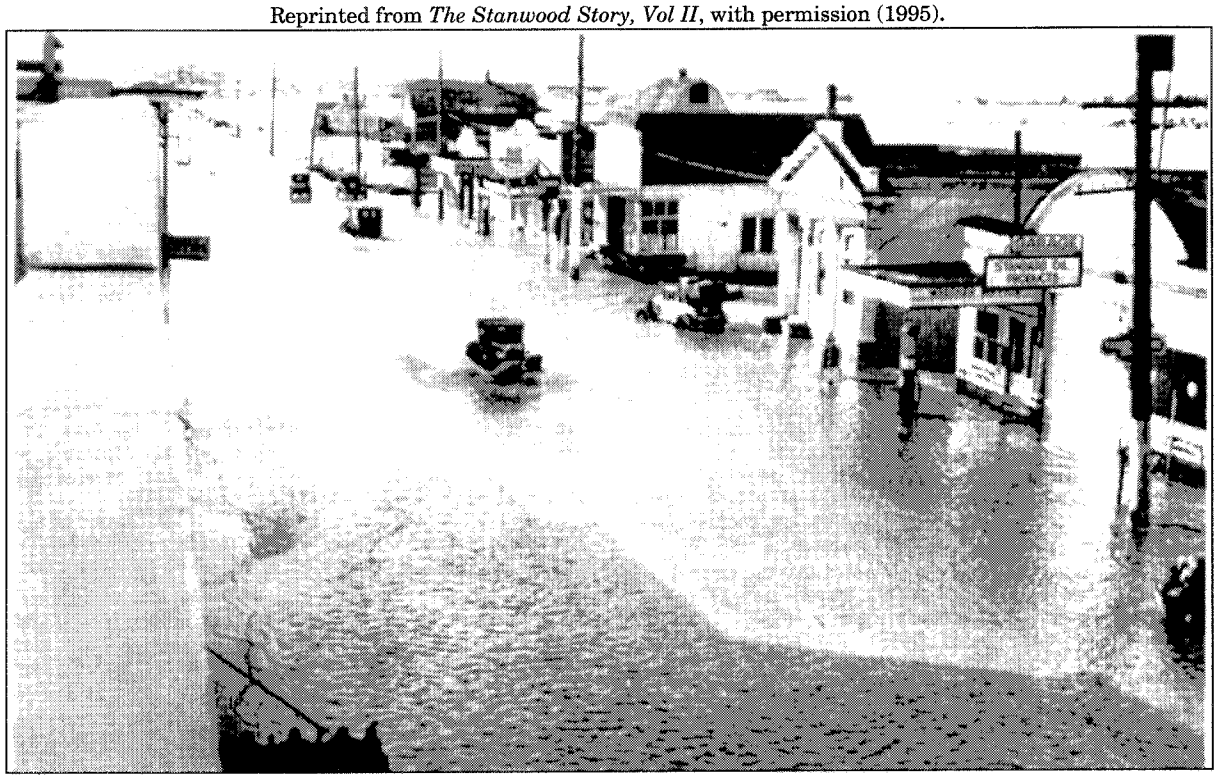
February 27, 1932 Flood

The estimated peak discharge rate of 65,000 cfs for the February 27, 1932 flood represents the highest recorded flow rate of any flood in the Stillaguamish River since the gages were installed. As warm, chinook winds increased snowmelt in the mountains, a large spring rainstorm combined with the snowmelt to cause a rapid increase in floodwaters beginning on February 25, 1932. By the 27th, water levels in Hatt Slough rose approximately 15 feet and inundated hundreds of acres of adjacent farmland (Twin City News, Mar. 3, 1932a).

On the same day, the dike protecting East Stanwood breached at several locations, sending a rush of water into the city. Within several hours, most of the town was standing in water up to 12 inches deep (Figure 14). While water entered many residences and businesses in the area, actual damage to Stanwood caused by the flood was limited. In many cases, flooded businesses removed their goods from floors and low shelves before they were damaged (The Twin City News, Mar. 3, 1932b). While large deposits of sand and gravel on some farmlands in the area were considered detrimental to agriculture, most farmers considered deposition of silt beneficial (The Twin City News, Mar. 3, 1932c).

Figure 14: February 27, 1932 - East Stanwood, Washington.

Reprinted from *The Stanwood Story, Vol II*, with permission (1995).



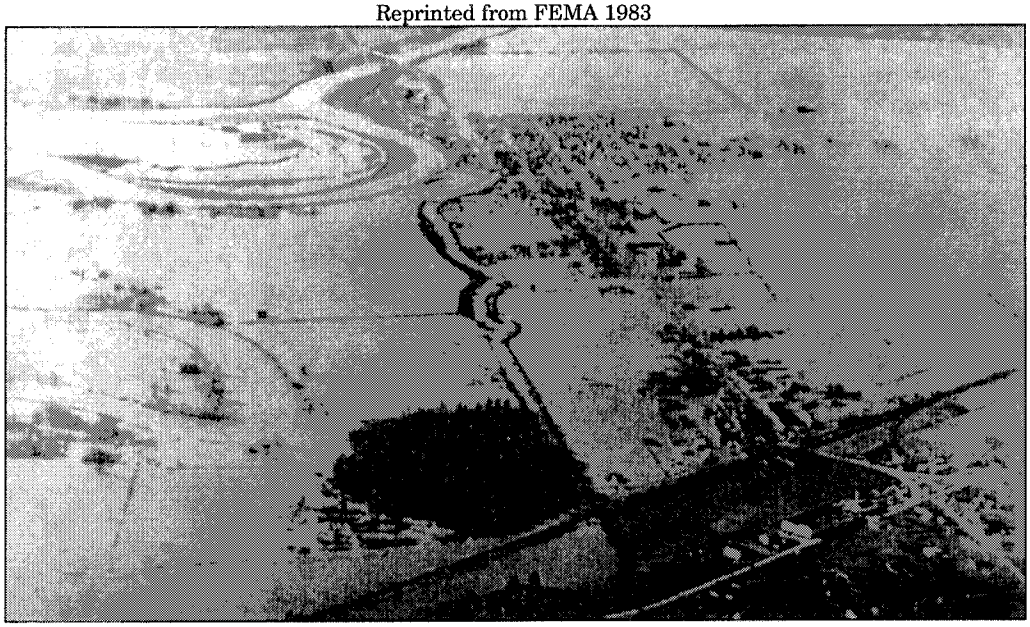
February 10, 1951 Flood

The February 10, 1951 flood on the Stillaguamish peaked at a flow rate of approximately 61,000 cfs. Like most floods from the river, this extremely high flow was generated by heavy rainfall over the region combined with snowmelt in the mountainous areas of the basin (Corps 1967). Heavy rains from the 9th to the 11th were produced by a strong flow of warm, moist air from the southwest. The precipitation gaging station at Silverton recorded more than 6 inches of rainfall in a 24-hour period, more than 12 inches during a 72-hour period, and an hourly maximum of 0.45 inches. At the same time, snowmelt increased after freezing levels rose to an elevation of roughly 6,000 feet. The resulting flow in the Stillaguamish crested at an elevation of 19.82 feet at Arlington (Corps 1990). This marked the highest crest elevation recorded during the period of record, exceeding even the 1932 flood.

The flood inundated most of the lower valley between Silvana and Stanwood (Figure 15). Most of downtown Silvana was underwater and agricultural areas on the outskirts of Arlington were inundated. On February 10, floodwaters in the Stillaguamish overtopped river dikes near Stanwood and East Stanwood, and eventually caused several large breaks in these dikes, inundating both towns and the surrounding area (Twin City News, Feb. 15, 1951a). The levee breaks were considered too large to repair until flood levels in the Stillaguamish began to recede.

Figure 15: February 10, 1951 - Aerial View of Stanwood Looking West.

Reprinted from FEMA 1983

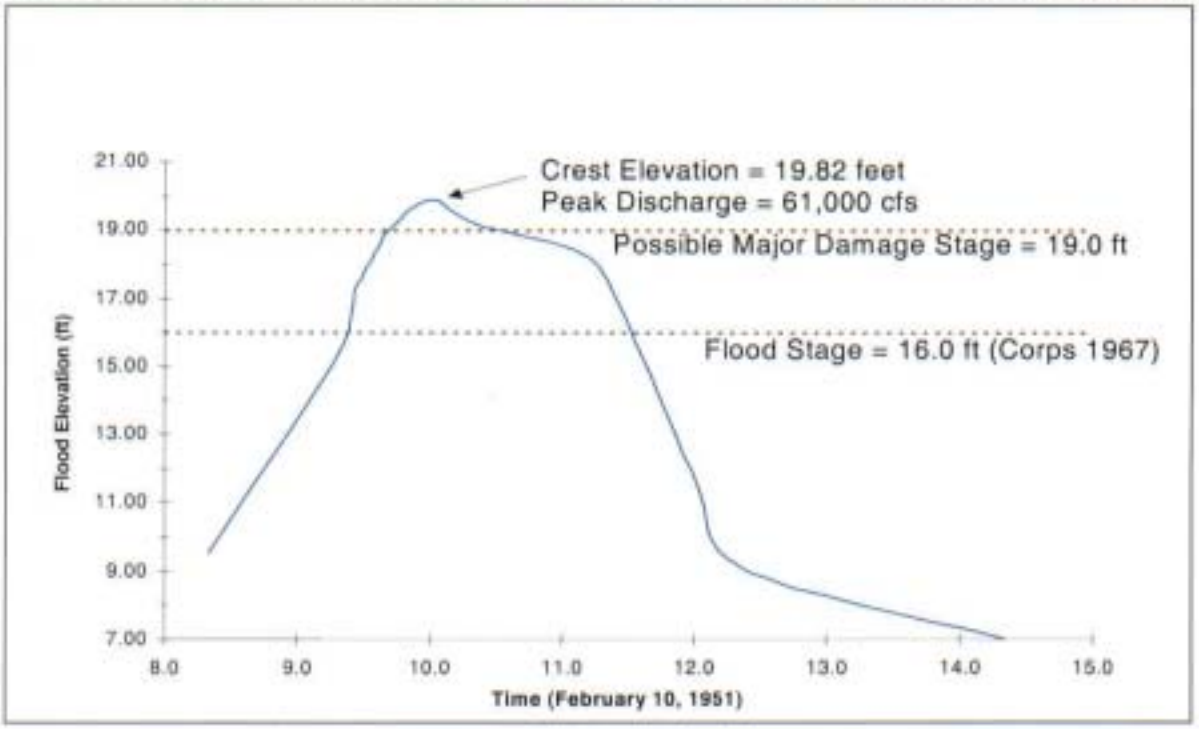


To compound matters, levees were also breached by high flows in the Skagit River so that the entire valley floor was inundated by floodwater from both rivers. Stanwood was reported to have an average of roughly 10 inches of water in its streets (Seattle Times, Feb. 15, 1951), though some locations in the area were standing in more than two feet of water (Twin City News, Feb. 22, 1951).

Sea dikes along Skagit Bay, originally built to prevent inundation from high tides, impounded the floodwater and prevented the area from draining. As a result, dikes constructed along the Stillaguamish directly south of Stanwood were dynamited to help drain the trapped floodwaters more quickly (Twin City News, Feb. 15, 1951b). The 1951 flood was the last time in which the Skagit River overtopped its levees to flood the Stanwood and East Stanwood area.

As shown in Figure 16, the river remained above flood stage (elevation 16 feet) at Arlington for 55 hours and above the possible major damage stage (elevation 19 feet) for 17 hours. The Corps (1967) estimated the total damage from the 1951 flood in the Stillaguamish basin to be approximately $339,000 (1965 dollars). Just over one-third of this was attributed to damage to buildings, their contents, and to business losses. Slightly under one-third was agricultural losses. Shortly after this flood, the Corps declared the western Washington region a disaster area.

Figure 16: February 10, 1951 Flood Hydrograph at Arlington, Washington (Corps 1967).



November 23, 1959 Flood

Another significant flood occurred November 23, 1959, with an estimated peak flow of roughly 59,600 cfs on the mainstem. A series of three storms over the region between the 17th and the 22nd produced two major peaks on the Stillaguamish less than three days apart. The initial peak crested above flood stage on the 21st and then receded for about 24 hours. Flows began to increase again on the 22nd and produced the maximum crest on the 23rd (Corps 1967).

Floodwaters from the Stillaguamish inundated much of the floodplain south of Stanwood and East Stanwood. As flood levels increased, a break in the dike along Irvine Slough allowed large volumes of water to flow directly into Stanwood and East Stanwood (Twin City News, Nov. 26, 1959). While the break was being repaired, the levee on the south side of the slough further downstream was dynamited to help drain the slough and minimize flooding (Figure 17and Figure 18).

The November 23, 1959, flood was the last flood event in which the Stillaguamish River flooded the downtown area of Stanwood. The Corps (1967) estimated the total damage throughout the basin to be $272,000 (1965 dollars). Just over a third of the damage was from agricultural losses, with roughly another third due to damage to buildings and their contents, and business losses. Other losses included flood-fighting efforts, restoration of flood management structures, and damaged roadways, railroads, and utilities.

Figure 17: November 1959 - Efforts to Repair Breach on North Side of Irvine Slough.

Figures 17 to 20 Reprinted Courtesy of Stanwood/Camano News.

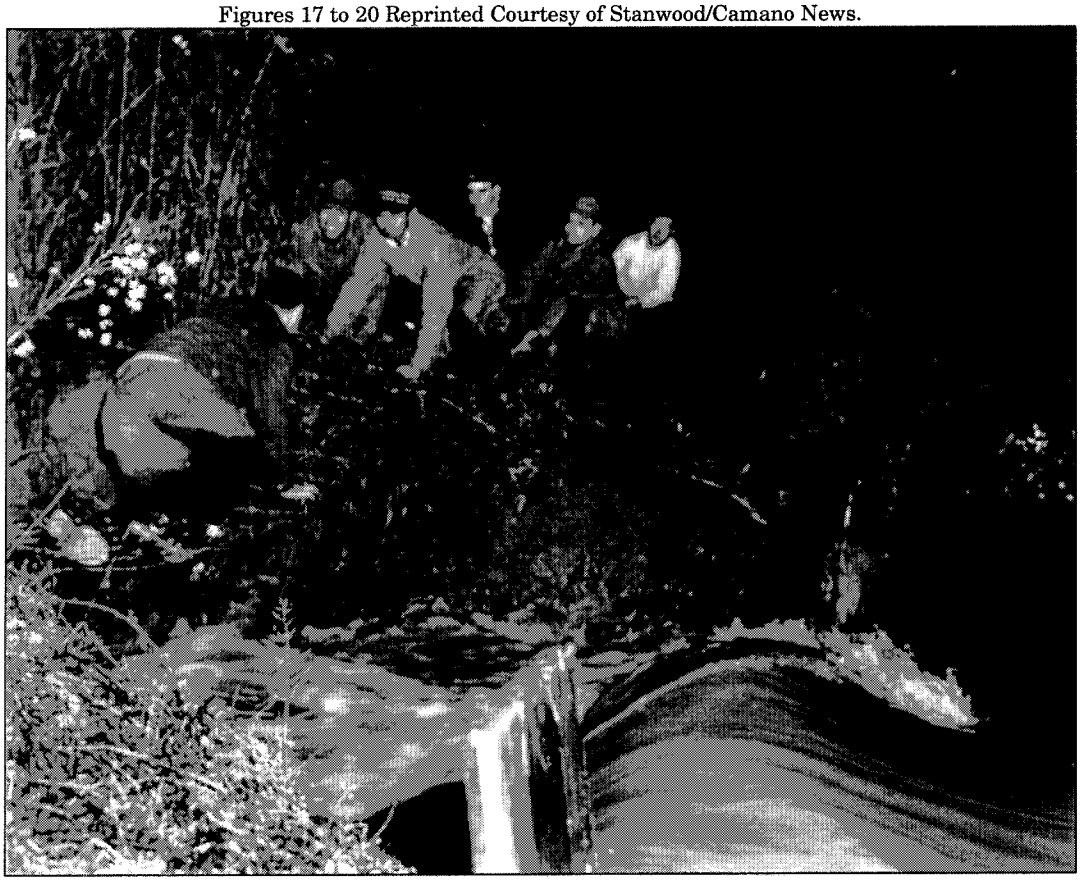


Figure 18: November 1959 - Channel cut through dike on North Side of the Old Stilly, discharging trapped water into the Stillaguamish.

Figure 19: November 1959 - Aerial View of Stanwood Looking West.

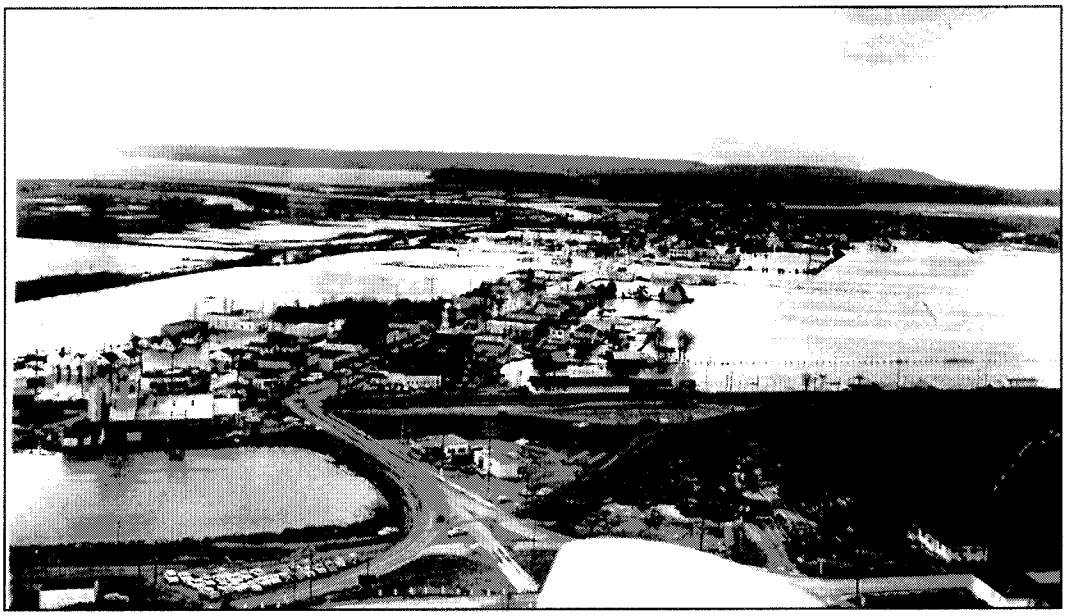
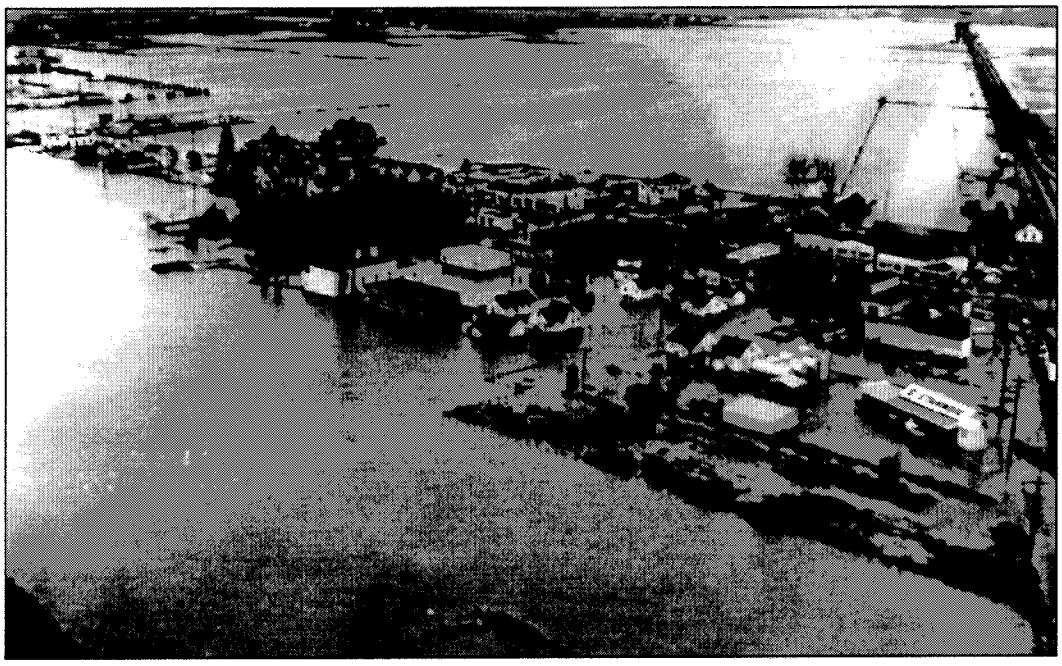


Figure 20: November 1959 - Aerial View of Stanwood.



December 15, 1959 Flood

Less than a month after the November 1959 flood, the Stillaguamish River flooded again. Prior to this flood, which crested on the 15th of December, the basin was saturated by almost continuous rainfall. Flows in the river rose and fell very rapidly, remaining above

base flow conditions for only about two days (Corps 1967). The peak discharge at Arlington was approximately 54,800 cfs.

The December 15, 1959, flood was of smaller magnitude and shorter duration than the earlier floods, and resulted in less damage in the basin. The flood affected mainly agricultural areas in the lowlands between Silvana and East Stanwood. (Twin City News, Dec. 17, 1959).

December 3, 1975 Flood

The next major flood occurred on December 3, 1975. On that date, the peak flow at Arlington was estimated at approximately 46,500 cfs. The Corps (1979) estimated that this peak flow had a recurrence interval of about 8 years. The total area inundated by the flood was approximately 7,900 acres, while the total damage, in 1975 dollars, was estimated at $1,474,000. This flood caused the greatest damage to the region since the floods of 1959. Flooding throughout Snohomish County led to the declaration of the county as a federal disaster area on December 13, 1975.

According to local reports, floodwater entered the town of Stanwood at two locations (FEMA 1983). Low-lying areas in the communities of Florence and Silvana were flooded as well as farmlands south of Stanwood. According to a local newspaper, the National Guard delivered over 15 truckloads of dead livestock from Snohomish County to the landfill.

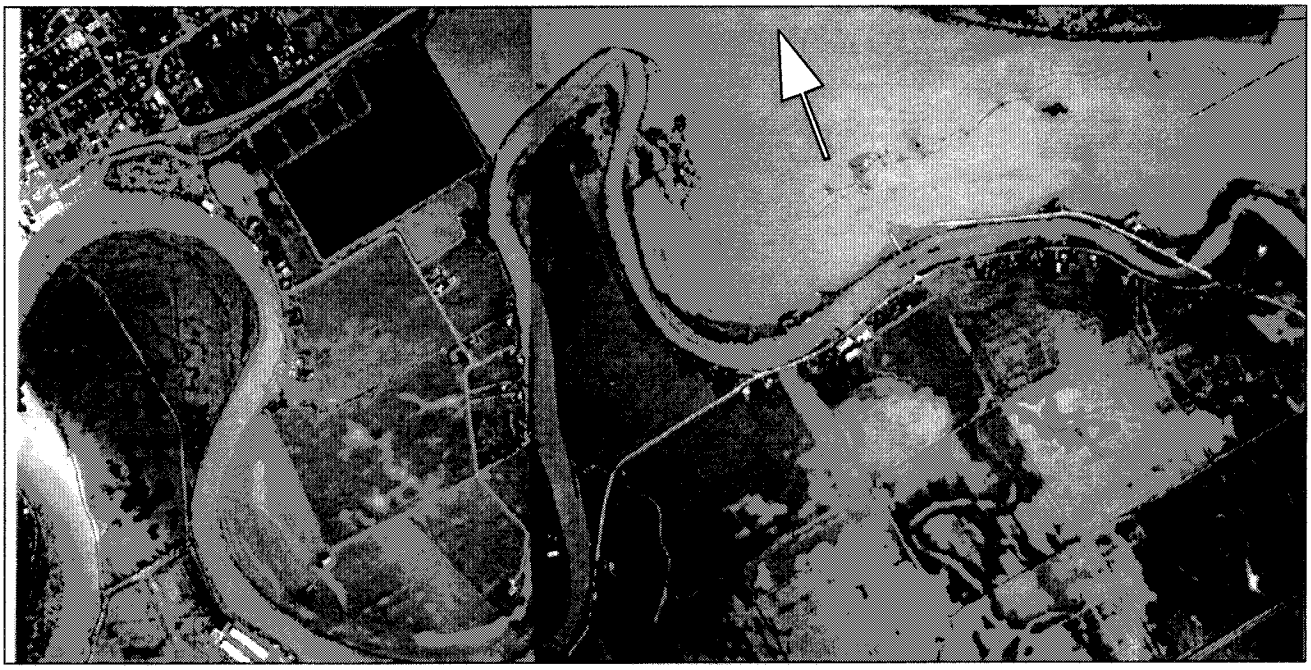
December 2, 1977 Flood

The Corps (1979) estimated the December 2, 1977 flood to have a peak flow of approximately 57,000 cfs at Arlington with an estimated recurrence interval of about 3 years. Flooding occurred in Arlington and neighboring areas. Sandbags were placed along River Road, along Marine Drive at the highway overpass, and along Twin City Foods in west Stanwood (Stanwood News, Dec. 7, 1977).

Sandbagging prevented flooding in the City of Stanwood, although the farmlands to the south of town were flooded. Other flood-fighting efforts included excavating a channel through a dike along the Old Stillaguamish to allow the Irvine Slough to drain more quickly into the Stillaguamish. On December 10, 1977, Snohomish County was again declared a federal disaster area.

Figure 21 indicates that while some minor flooding hazard was experienced directly west of the wastewater treatment lagoons, the majority of the flooding occurred on the floodplain to the east (north arrow is approximate).

Figure 21: December 1977 Flood - Aerial Photographs at Stanwood (Corps).



December 1979 Flood

A combination of high tides in Puget Sound and high flows in the Stillaguamish River caused the river to flood again in December 1979. Flood levels crested on the 17th, roughly 2 feet above flood stage (Seattle Times, Dec. 18, 1979). This flood was uncharacteristic for the Stillaguamish because, although flood levels were not exceptionally high, the river remained above flood stage for a long period of time (Stanwood News, Dec. 19, 1979).

According to newspaper reports stores and businesses in Silvana were flooded and many outlying areas were cut off as roads became inundated. A 20-ft hole broke open at a levee on Hatt Slough, resulting in the inundation of adjacent farmlands (Seattle Times, December 16, 1979). At Stanwood, emergency sandbagging was once again required along River Road and a temporary dike was constructed across Florence Road at the SR532 overpass. At the west end of Stanwood, additional sandbagging was needed after floodwaters inundated portions of the business district (Seattle Times, Dec. 16, 1979). To help drain the flooded area directly south of Stanwood, a portion of the Stillaguamish River dike near the southwest corner of the sewage lagoon was removed (Stanwood News, Dec. 19, 1979). For the third time in the decade, flooding in Snohomish County resulted in the county being declared a federal disaster area.

November 10, 1990 Flood

The first of two significant floods during November 1990 peaked on the 10th of the month. Conditions in the Stillaguamish basin prior to the flood contributed to the high volume of flow in the river. Precipitation volumes during the previous month were as high as 200 percent of normal in western Washington, which saturated the ground and raised the

snowpack above normal levels (Corps 1991). A tropical storm from the Pacific dropped 6.1 inches of rain at the Verlot precipitation gage (South Fork) between November 8 and 10. Runoff from the combination of rainfall and snowmelt caused a peak flow of 60,700 cfs at Arlington, estimated by the Corps to have a recurrence interval of 15 years [Converse Consultants NW (CCNW) 1991]. The crest of the flood reached an elevation of 19.35 feet at Arlington, well above the established flood stage of 14 feet.

As floodwater inundated the lower valley, the small communities of Silvana, Norman, and Florence were isolated. Much of Silvana was underwater and businesses reported having up to 10 inches of water in their buildings. Swift currents in the Silvana and Norman area carried off sheds and small out-buildings. Flood debris cluttered SR 530 in Silvana, and Larson Road near Norman. According to newspaper reports, several county roads were inundated including Leque Road, Thomle Road, Marine Drive, and Norman Road between 28th Ave NW and 36th Ave NW. Flood damages in the North and South forks of the Stillaguamish and at Arlington were minimal, although Highway 9 north of Arlington was closed temporarily.

Homes along Leque Road, south of Stanwood, received extensive flooding. Houses along Thomle Road were inundated. The wooden bridge linking residents of the Leque Road area to Stanwood was inundated and eventually broke lose and floated. Flood elevations reached the eves of some low-lying houses in this area, according to newspaper reports.

According to local news reports (Stanwood/Camano News, Nov. 14, 1990), this flood overtopped the dikes surrounding the sewage lagoons at the wastewater treatment plant for the first time since it was built in 1962. Floodwater from the adjacent field to the east overtopped the sewage lagoon dikes. After maximizing the capacity of the lagoons, the floodwater overtopped the south dike of the lagoon, inundating the entire floodplain directly south of the wastewater treatment plant, and flooding all 27 homes in this area.

At the west end of Stanwood, floodwater began to overtop SR532 and flow into town, flooding several businesses, until a temporary sand dam was constructed to prevent further overtopping of the highway. An even larger temporary dam was built at the east end of town across Marine Drive and the railroad tracks beneath the SR 532 overpass. Water levels rose as high as four feet on the riverside of this larger dam (Stanwood/ Camano News, Nov. 14, 1990).

Flood control experts warned that the levees and dikes were left so weak from the November 10 flood event that another major disaster could occur. Repairs could not be made in time to prevent more flooding in the event of heavy winter or spring rains.

November 24, 1990 Flood

Less than two weeks later, a flood of even larger magnitude occurred on the Stillaguamish River. The ground was still saturated from the previous flood and continual rainfall when another tropical storm arrived from the Pacific. A total of 9.6 inches of precipitation was measured at the Verlot weather station between the November 21 and 25, surpassing the previous storm total by over three inches (Corps 1990). This weather station is located in the upper South Fork Stillaguamish watershed in the Cascade Mountains to the east. The

rainfall intensity peaked on November 24, yielding 2.9 inches of rain and causing a peak flow in the Stillaguamish at Arlington of 64,700 cfs on that day. This peak flow rate, estimated by the Corps (1990) to have a recurrence interval of 30 years, approached the highest flow ever recorded at Arlington, which was 65,000 cfs during the February 1932 flood. However, the crest elevation at Arlington of 20.0 feet not only exceeded the established flood stage by six feet, but also exceeded the 1951 flood crest to become the new highest on record.

According to newspaper reports nearly 30 families in the Stillaguamish valley were evacuated. The community of Silvana was again mostly underwater. Thousands of homes were without power and some lost use of their telephones. Large portions of Norman Road were washed out and mudslides on SR530 between Stanwood and Silvana, caused by the heavy rains, limited access between the cities. Many road closures occurred, including Highway 9 north of Arlington and the dike road at SR530.

A local newspaper (Stanwood/ Camano News, Nov. 28, 1990) reported that the levees around the sewage lagoons were again overtopped and the homes south of Stanwood in the Leque Road neighborhood were again flooded, while flood levels were even higher than the previous flood. As with the previous flood, temporary dikes were built across Marine Drive and the railroad beneath the SR 532 overpass as well as along the west end of Stanwood, preventing the downtown area from being flooded by the Stillaguamish River.

On November 26, 1990, following the second of the two large floods of the month, Snohomish County was again declared a federal disaster area. In 1991, the levees around the sewage lagoons were raised to an elevation of 12 feet, two feet above the estimated 100-year flood elevation.

November 8, 1995 Flood

The first of two major flood events in November 1995 peaked on the 8th of the month. These back-to-back flood events were similar to the two floods that occurred in November 1990.

The City of Stanwood prepared for the high floodwaters by constructing a concrete block barrier at one of the town's lowest, most vulnerable spots, near Florence Road under the railroad bridge. Preparations were made well ahead of time. The water elevation did not reach the barrier, but crept to within just a few feet of it. Floodwaters in the Stanwood area receded very slowly. According to a local newspaper, weather officials warned that a threat still existed since the ground was saturated with water and more rain was forecasted.

November 29, 1995 Flood

Nearly three weeks later, a warm weather front from Hawaii, called the Pineapple Express, brought heavy rain that caused more flooding due to the saturated soil conditions from previous flooding. While the flow in the mainstem of the Stillaguamish River was not determined during this flood event, the peak flow at that station was estimated to be between 46,500 cfs and 57,000 cfs.

This estimate was obtained by using an established relationship between historical flow measurements for the gaging stations on the mainstem Stillaguamish River at Arlington and on the North Fork Stillaguamish River near Arlington. This relationship was applied to flow data from the North Fork on November 29, 1995 to project a flow estimate for the mainstem. Flow data for the December 1975 and December 1977 floods were used to establish a relationship between data from the two gages. The North Fork Stillaguamish gaging station measured a peak flow of 29,500 cfs on November 29, 1995.

A local newspaper reported that the Stillaguamish valley farmland, just south of Stanwood, was covered by six or seven feet of water. However, the flooding from the Stillaguamish River was not as widespread as in November 1990.

Stanwood prepared for the flooding by constructing temporary dikes, including a crucial dike located atop Florence Road at the city limits under the railroad bridge. In addition, sandbags were placed on Larson Dam (dike at the upstream end of Irvine Slough) to prevent overflow into Irvine Slough. The dikes prevented over two vertical feet of Stillaguamish River water from inundating the city. After the 1990 floods, because the lagoon levees were elevated two feet, the lagoons did not overtop.

February 8, 1996 Flood

Rainfall combined with warmer temperatures caused flooding and landslides to occur on February 8, 1996. The peak flow in the Stillaguamish at Arlington was estimated to be greater than 50,000 cfs. Flood depths reached six feet or higher throughout the valley, but most farm families who are long accustomed to seasonal flooding waited out the high water in their homes. A local newspaper reported that the valley floods caused no major damage.

There was no flooding from the Stillaguamish River within the Stanwood city limits. To prevent flooding, the SR 532 railroad overpass was plugged with ecology blocks, plastic sheets, and sandbags. In addition, sandbags were placed on Larson Dam again. According to Chuck Hazleton, Stillaguamish River Flood Control District Commissioner (Personal Communication 2000), five breaches occurred in dikes on the Old Stillaguamish River channel and three in Church Creek (Joergenson Slough).

March 19, 1997 Flood

Between December 29, 1996 and January 1, 1997, three days of snow (up to 21 inches in Stanwood) were followed by high temperatures and heavy rain, which caused only minor flooding. The Stillaguamish River stayed within its banks between Stanwood and Warm Beach.

A few months later, melting of a late winter snowfall that occurred on March 12th, caused more severe flooding on the main rivers. The estimated peak flow for the Stillaguamish at Arlington was 51,000 cfs on March 19, 1997. Farms and homes in the Stillaguamish River valley were inundated as dikes breached. A local newspaper reported that the rise in water level in the Stillaguamish was the fastest in memory (approximately 3 feet per hour).

As usual during floods, Warm Beach residents had to use I-5 to get to Stanwood because Marine Drive was closed due to high water. The City of Stanwood escaped flooding, but the water came to within one foot of overtopping dikes. Thirteen vehicles were inundated by floodwaters at the Stanwood Park-and-Ride lot just south of SR 532 near Florence Road. The cars could not be towed because of the rapid rise in water elevation.

Figure 22: March 19, 1997 Flood - A Farmhouse and Outbuildings Stranded in the Valley.

(Photographs 22 to 24 are Reprinted Courtesy of Stanwood/Camano News)

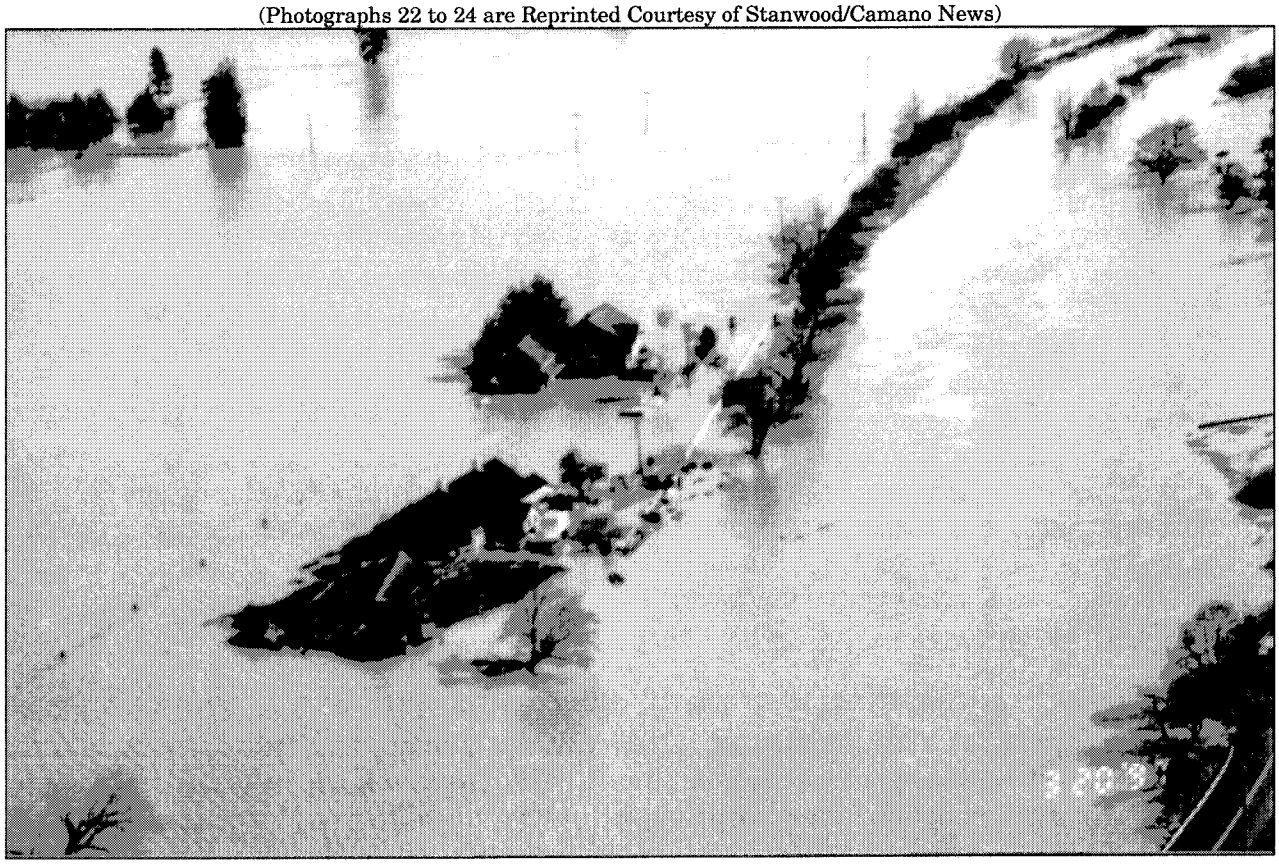


Figure 23: March 19, 1997 Flood - Flooding in the flats between Arlington and Stanwood.

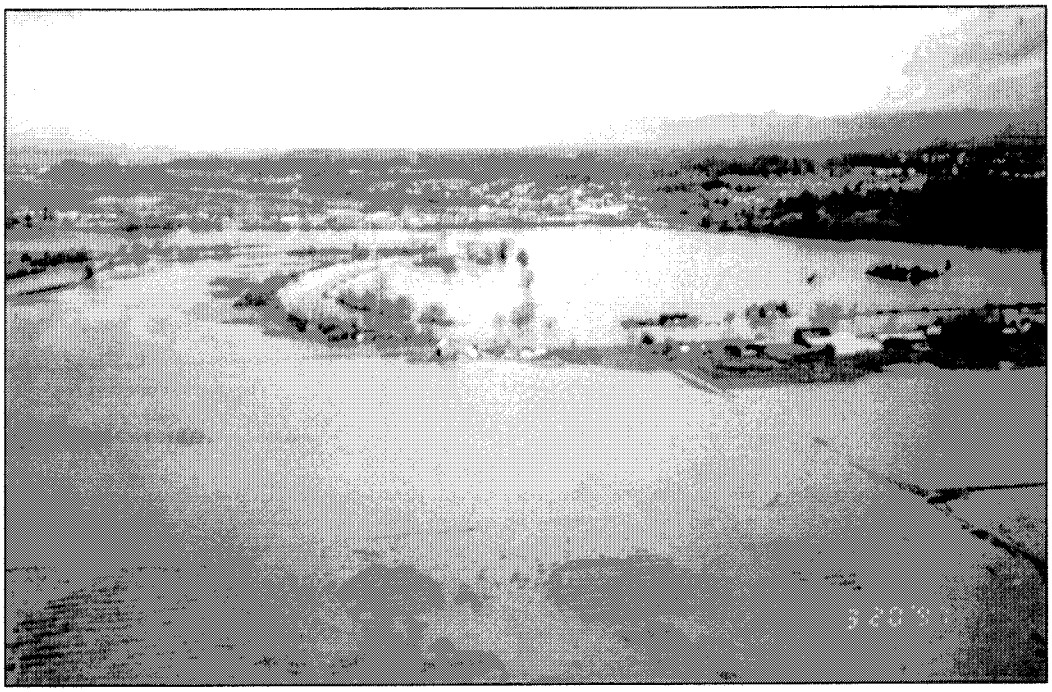


Figure 24: March 19, 1997 Flood - Flooded Vehicles in the Stanwood Park-and-Ride Lot.

5.1.2 PERSONAL ACCOUNTS

In addition to historical documents, staff interviewed several long-time residents of the Stanwood area and they provided their personal accounts of the flood events that impacted the City of Stanwood and surrounding areas. Their insights were appreciated. These residents included:

- ✓ *Mr. Ole Eide*. Mr. Eide has been a resident in the Stanwood area since 1908. He owns a farm on West Pass and used to experience steamboat traffic through the pass. Much of the river's main flow passed through Stanwood until about 1916.

- ✓ *Mr. Nels (Sweed) Bodin*. Mr. Bodin was born in Livingston Bay in 1922 and has lived on the Stillaguamish River for over 40 years. He was a boat builder and commercial fisherman. He currently lives south of the smoke stack in Stanwood.

- ✓ *Mr. Stanley Matterand*. Mr. Matterand has been a Florence Island resident since he was born in 1921. In 1877 his grandfather, Ole S. Matterand, diked much of the island for farming. Mr. Matterand has been a farmer his entire life.

- ✓ *Mr. Francis H. Giard, Jr.* Mr. Giard Jr. was born in East Stanwood and served on the Stanwood City Council. He was a farmer and backhoe operator for years. In 1964 he moved to Camano Island. As a duck hunter for decades, he noted how the estuary has built up over the years.

Some of these residents constructed clay and sod dikes with horses and as documented, these structures were originally built to prevent saltwater from inundating farmland during high tides. Mr. Eide ran a crew of 20 men that constructed a dike around Douglas Slough near Stanwood. This crew was able to move 3 to 6 yards of material a day. He also led the crew who assisted in the construction of 22 of the 26 Corps' sites that were built on the mainstem in the 1930s.

As documented in several Corps' reports, these residents remember boats removing snags from the river. They verified that tugboats used to travel up and down Irvine Slough in the early 1900s and that steamboats 100 feet in length were once able to turn around in the Slough, which is now less than 50 feet wide and 6 feet deep in most places. These residents also noted that the water surface level drops dramatically from the seven culverts on the southeast corner of the lagoons to the mouth of Irvine Slough.

These residents sandbagged a cross-dike at Mill Town and as further evidence of the impacts of flooding on the City of Stanwood, these residents would use skiffs to get from home to downtown. In the 1921 flood, Mr. Eide recalled during flood events that boats were able to travel from the Skagit Bay, up the main street of Stanwood, south to Florence Island and exit to Hatt Slough.

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CHAPTER 6

HISTORY OF FLOOD MANAGEMENT

CHAPTER 6 - HISTORY OF FLOOD MANAGEMENT

6.0 Historical Flood Management – Constructed Projects

The lower Stillaguamish west of Arlington has flooded on numerous occasions over the past century. This chapter documents the history of flood management, which includes projects that were constructed and studies that were conducted.

The period between 1860 and 1960 witnessed significant changes in the development of the Stillaguamish basin and in the attitude of floodplain property owners toward floods. Initially, logging was the principal industry in the river basin and navigation of the river, rather than flood management, was the principal concern of residents. As the chief industry of the basin shifted from logging to agriculture, particularly dairy farming, flooding from the river was still regarded by most as only a temporary nuisance. As development increased, flood damage continued to increase and flood management actions became a higher priority.

The first known flood management projects involved the construction of dikes along the Stillaguamish River and Skagit Bay in the early 1870s (Essex 1982). While some dikes were built by diking districts, private landowners independently built many along the river and Hatt Slough (Corps 1930). These early dikes were built only high enough to prevent inundation of the adjacent land during high tides, rather than to prevent flooding caused by high river flows (Corps 1967).

The first navigation project, authorized by the River and Harbor Act of 1882 (expanded in 1892), involved the periodic removal of snags as well as a limited amount of dredging in the Stillaguamish River (Corps 1930). This activity was confirmed by the personal accounts of long time residents (see Chapter 5). Two additional projects in the Stillaguamish River attempted to restore flow conditions in the main river and Hatt Slough to their pre-1906 conditions. Prior to 1906, a significant amount of debris had naturally collected in Hatt Slough and severely restricted flow except during high flood stages. Severe floods during November 1906 removed this debris and significantly increased flows through the slough at all river stages and decreased water depths in what is now the Old Stillaguamish River channel, but was then the main river channel.

To divert more flow back into the main river, which is now the Old Stillaguamish River channel, a submerged dike was constructed across the head of Hatt Slough in 1909. Later that year, flood flows in the river breached and destroyed the dike. The River and Harbor Act of 1910 then authorized rebuilding the dike across Hatt Slough to an even higher elevation so that, once again, nearly all low flows would be diverted into the former main river channel and only flood flows would enter Hatt Slough. Some time after 1915, the dike was again destroyed by the river, resulting in nearly all low flows passing through Hatt Slough rather than the former main river. Finally, dredging of the former main channel was conducted during both 1923 and 1930 to improve navigation of the river (Essex 1995).

During this period, a number of flood structures were constructed to prevent migration of the Stillaguamish River channel. The Flood Control Act of 1936 authorized the Corps to install structures on the Stillaguamish River between Arlington and the head of Hatt Slough, as well as on Cook Slough, to reduce bank erosion and control channel changes (Corps 1967). These structures included 36,000 linear feet of bank revetments at 26 locations on the river and Cook Slough. Others included a concrete weir at the head of Cook Slough to reduce flow through the slough, and two cutoff channels in Cook Slough to eliminate sharp bends in the slough.

In addition, the Works Progress Administration (WPA) completed a number of projects in the Stillaguamish River prior to 1941. These structural changes primarily consisted of additional bank revetments, dike repairs, and snagging (Corps 1967). The Corps also altered the river channel during the 1940s to redirect most of the flow in the Stillaguamish River through Hatt Slough to Port Susan.

While these structures were effective in stabilizing the channel of the Stillaguamish River, they did little to reduce the flood damage suffered in the 1951 and 1959 floods (Chapter 5). To help relieve flooded areas, a common flood-fighting practice of this period involved blasting holes in the levees along the Stillaguamish River to allow floodwater trapped behind the dikes to drain back into the river.

A chronology of the projects constructed on the mainstem of the Stillaguamish River is provided in Table 6.

Table 6: Chronology of Constructed Projects on the Stillaguamish River and Surrounding Area.

Date	Flood Management Milestone
1870s to early 1900s	Dikes constructed along river banks and Skagit Bay, primarily to prevent inundation by high tides.
1882, 1892	River & Harbor Act authorized limited dredging of river channel.
1909	Submerged mattress cells built at Hatt Slough to divert flow into main river channel (now the Old Stillaguamish), but dike destroyed by river later that year.
1910	River & Harbor Act authorized rebuilding the mattress cells at Hatt Slough, but river destroyed the mattress cells again after 1915.
1923, 1930	Downstream portions of the Stillaguamish channel dredged.
1930s	WPA and Corps performed channel and dike changes and repairs.
1940s	Corps altered river channel to divert most flow back into Hatt Slough instead of main river channel (according to local information, although not confirmed).
1962	Wastewater treatment plant completed between Irvine Slough in Stanwood and river channel with dikes around sewage lagoons.
early 1960s	SR 532 completed, which acted as a levee to protect Stanwood from Stillaguamish.
1979	Pump station constructed at mouth of Irvine Slough, only 2 of 4 pumps installed.
1991	Levees around Stanwood Wastewater Treatment (WWTP) Plan raised approximately two feet and extended across the mouth of Irvine Slough. Also, 7 culverts installed in Stillaguamish River levee near the southeast corner of the WWTP to drain floodwaters.

6.1 Historical Flood Management – Studies Conducted

Flood management studies have been conducted by the Corps, the City of Stanwood, and by FEMA for flood insurance purposes. While the Corps studies varied significantly in scope, each included flood management alternatives, typically structural alternatives that would increase flood protection for the lower Stillaguamish River basin, specifically around the Stanwood area. The City of Stanwood conducted its own flood management studies, which primarily addressed local flooding hazards and emphasized structural flood management alternatives. Flood insurance and disaster studies documented flood conditions, particularly following historical flood events, and either made nonstructural recommendations to reduce flood damages or else did not analyze flood management alternatives at all.

The recommended actions in most of the studies presented below were never implemented primarily because of the lack of adequate matching funds. In the construction phase of most Corps projects, a local sponsor, which is usually the jurisdiction that benefits from the project, is responsible for 35% of the total project costs. In addition, as with most projects, the benefits of a project must outweigh the costs of constructing it. Because of that requirement, most studies focused on the protection of Stanwood and surrounding areas.

6.1.0 CORPS STUDIES

1930s to 1960s

The River and Harbors Act of 1925 and 1927 authorized the United States War Department, through the Corps, to investigate specific navigable streams in the United States, including the Stillaguamish River. As a result, the War Department conducted the first study related to flood control of the Stillaguamish River. The study, which also investigated navigation, power development, and irrigation issues, was summarized in a report published in 1930 (Corps 1930). Several structural measures to provide flood relief were analyzed, including storage reservoirs, dikes, and flow diversion. The study concluded that the federal government should not pursue any of the identified projects since flood damage was not significant enough to justify the cost of the proposed projects.

Increasing development in the Stillaguamish basin resulted in increased flood damage from several large floods during the 1950s. These increasing flood damage costs prompted the federal government to identify the most economical means of reducing flood damage in the basin.

In 1960, Congress granted the Corps authority to gather information on floods when requested to do so by a local sponsoring agency. The Washington State Department of Conservation (now Ecology) then requested the Corps to provide information on the general flooding characteristics of the Stillaguamish River.

In a 1963 report, the Corps described the general conditions that cause flooding in the basin, listed the major historical floods in the basin, estimated the damage associated with historical floods, mapped historical flood limits and flood levels, and suggested a variety of nonstructural measures to reduce flood damage (e.g., home elevation). In addition to providing useful flood information, this study was to serve as a guide for local agencies and developers so that new construction would not increase the amount of damage that occurred during a flood (Corps 1963).

The Corps completed an additional review of Stillaguamish flooding in 1967. This report reviewed previous flood related studies, updated the flood history, and calculated flood damages, and investigated the feasibility of alternatives designed to reduce flood damage downstream from Silvana. Two alternatives, dismissed as economically unfeasible and politically unacceptable, included flood control reservoirs in the upstream reaches of the Stillaguamish and the relocation of existing development from the floodplain to areas outside the flood limits. The third alternative considered the construction of levee and channel changes as a means of reducing flood damage. The most promising combinations of levee and channel changes were developed into three plans. Based on the benefit-to-cost ratios, a plan was recommended for an estimated total cost of $7,250,000 (1966 dollars), 90 percent of which was proposed for funding by the federal government. The local share was therefore $750,000 (1966 dollars).

Several public hearings were held throughout the study to obtain input from residents and local officials on the flood control actions proposed by the Corps (1967). Although initial public reaction to the flood management was positive, the proposition failed by a substantial margin during a balloting of all property owners directly affected by the proposed plan to establish a flood control district. Thus the proposed project was left without a legally qualified sponsor, the study recommended against federal participation in implementation of the recommended project, and no action was taken.

Table 7: Previous Corps Flood Management Alternatives (1930s – 1960s).

Reference	Proposed Alternatives	Recommendation
CORPS 1930	1. Flood control reservoirs 2. Levees along both banks of the Stillaguamish 3. Flow diversion	No action due to high cost of alternatives
CORPS 1963	1. No structural alternatives proposed, only nonstructural (e.g., flood warning, floodproofing)	Unknown.
CORPS 1965	1. Levee & channel alterations (Plan B) • 3 mi levee on north bank of Stillaguamish • 2,000 ft of channel alterations in Stillaguamish • 4.5 mi levee reconstruction on Tom Moore Slough 2. Levee & channel alterations (Plan C) • 5.7 mi of levees on both banks of Stillaguamish • 5.7 mi of channel alterations in Stillaguamish • 4.5 mi levee reconstruction on Tom Moore Slough	Preliminary recommendation was Plan C
CORPS 1967	1. Flood control reservoirs 2. Flood plain regulation and relocation • Relocation of structures inside floodplain • Adoption of floodplain ordinances 3. Levee & channel alterations (Plan A) • Levees on both banks of Hatt Slough • Channel alterations in Hatt Slough • Cross levee to protect from Stillaguamish • Cross levee to protect from Skagit River 4. Levee & channel alterations (Plan B) • 3 mi of levees on north bank of Stillaguamish • 2,000 ft of channel alterations in Stillaguamish • Cross levee to protect from Skagit River • 4. 5. Levee & channel alterations (Plan C) • 5.7 mi of levees on both banks of Stillaguamish • 5.7 mi of channel alterations in Stillaguamish • Flow control structure for old Stillaguamish channel • Cross levee to protect from Skagit River 6. Set back levee alterations • Set back levees along Stillaguamish between Hatt Slough and Cook Slough	Plan C preferred, but no action recommended due to failure to create a local sponsoring agency

Flood Alternatives 1975

The next study was authorized by a Senate Select Committee on Water Resources Planning to determine the extent of flood protection needed in the Stanwood area, and whether federal assistance was justified or whether further study was merited. A public meeting was held in January 1973 to present the preliminary flood management alternatives being analyzed by the Corps (Everett Herald, Jan. 15, 1973).

A report published in June 1975 summarized the various flood management alternatives and concluded that a levee on the north side of Stanwood to protect against Skagit River flooding and a levee on the south side of Stanwood to protect against Stillaguamish River flooding would be economically justifiable (Corps 1979a). However, further study was suspended in 1978 when it was realized that a separate project to improve levees along the Skagit River could be expanded to eliminate the need for the north levee and that the south levee could be studied more quickly under the authority of the 1948 Flood Control Act.

Following that realization, the City of Stanwood requested the assistance of the Corps, under the authority of Section 205 of the 1948 Flood Control Act, to provide flood protection from the Stillaguamish River. The Corps conducted a reconnaissance study of the Stillaguamish River at Stanwood to determine if a more detailed study was merited.

Corps Reconnaissance Study 1979

The results of this reconnaissance study, published in February 1979 (Corps 1979a), concluded that a further study was merited.

Flood Damage Reduction Study 1980

Following this determination in the reconnaissance study, the Corps began a detailed flood damage reduction study in April 1979 (Corps 1980). A brochure published in July 1979 summarized the progress of the study up to that point. This brochure (Corps 1979b) explained that raising levees along the Skagit River to provide 100-year flood protection for Stanwood could not be economically justified and would not be included in the levee project on the Skagit as originally intended (see Flood Alternatives 1975 above). Consequently, a levee along the north side of Stanwood to protect the city from Skagit River flooding was again included in the flood damage reduction study for Stanwood.

Two areas of concern were identified in this brochure. The first was related to financing the project, since the proposed north levee would increase the project cost to the point at which the federal financing limit of $3 million would be exceeded. The second concern was related to the disturbance of existing wetlands along the Stillaguamish River by the levees proposed in the reconnaissance report.

As the flood damage reduction study continued, four levee alignments were developed and presented to Stanwood in December 1980. Despite some variation, each alignment formed a ring levee around the city. These alternatives were presented to the public in the form of a newsletter (Corps 1980) and another public meeting. The total project costs ranged from $3,665,000 to $4,907,000 (1980 dollars). Since the limit of federal financing was still $3 million, financing the project remained a concern. Environmental concerns were not alleviated either, since each proposed levee alignment would disturb some wetland areas along the Stillaguamish River.

Flood Hazard Reduction Study - 1989

In 1989, the Corps updated the 1980 study and printed a fact sheet in which one of the proposed levee alignments around Stanwood was chosen as the preferred alignment. The proposed levee alignment was modified to control adverse environmental impacts resulting from its construction. The total project cost was reduced to an estimated $2,450,000 (1989 dollars), of which the federal government would finance all but $610,000. As with each of the previous Corps studies, no action was taken because of the lack of funds from the city, so the study was terminated (Corps 1995).

Table 8: Chronology of Flood Management Studies and Resulting Recommendations.

Date	Flood Management Milestone
1925, 1927	River & Harbor Act authorized Corps to conduct a regional flood control study, but no flood control improvements recommended.
1936	Flood Control Act authorized channel alterations to river, but no action taken.
1960	Congress authorized Corps to conduct a regional flood control study, which recommended major levee and channel changes, but no action taken.
1966	Proposal to create flood control district in the City of Stanwood was soundly defeated in election, which led Corps to recommend against previously recommended levee and channel changes.
1970s	Corps conducted flood control study under authority of 1948 Flood Control Act, but no action taken.
1980	Corps study narrowed to protecting only the City of Stanwood; ring levee around the city recommended, but no action taken.
1983	FEMA published flood insurance studies for Snohomish County. No action required.
1989	Corps ring levee project updated, then put on deferred status. No action taken.
1993	Stillaguamish Flood Control District formed.
1997	Comprehensive Flood Hazard Management Plan drafted for Stanwood. Plan not finalized.
1998	Corps begins Section 205 Small Flood Study to reduce flood levels near the City of Stanwood. Snohomish County local sponsor. Agreement signed in 1999. Project on-going.
2000	Stillaguamish Comprehensive Flood Hazard Management Plan initiated to address flood hazards for Stillaguamish River basin.

Reconnaissance Study: Stillaguamish River Ecosystem Restoration General Investigation—1997

The Stillaguamish River Ecosystem Restoration Study was authorized by Section 209 of the Flood Control Act of 1962 (public Law 87-874), which allows the Corps to conduct a comprehensive study of the Puget Sound and Adjacent Waters in Western Washington.

A reconnaissance report was prepared as the first phase of the Ecosystem Study (Corps 1997) to investigate ecosystem restoration and flood damage reduction opportunities in the Stillaguamish River basin. Snohomish County requested this study be conducted under the Puget Sound and Adjacent Waters Authority. Action alternatives from the study include:

- **City of Stanwood Flood Damage Reduction.** One part of this alternative includes building a levee on an existing road to protect Stanwood from the north against the Skagit River. An overtopping section of the levee would be built to allow the waters from the north to spill back into Skagit Bay. Another portion of the project involves an emergency railroad and road closure under Highway 532 to protect Stanwood from flooding from the Stillaguamish River to the south. As part of this project, the Irvine Slough levee would be raised 4 feet along Highway 532. To help floodwater exit more quickly, an additional culvert and two 50 horsepower pumps would be added at the outfall to the South Pass, which flows to Port Susan.
- **Three Lobes Project.** This alternative is located along the lower two miles of the old Stillaguamish channel and would serve two purposes: 1) provide approximately 2,000 acre-feet of additional flood storage capacity, and 2) provide off-river habitat for salmon and trout. This project would use three of the four lobes of the old Stillaguamish channel near Stanwood to provide flood control storage, improved floodway, and additional natural valley storage. The project includes removing some sections of existing levees, building new levees, and creating side-channels in the lobes. All four lobes would be planted along the entire length of the channels on both sides with a riparian buffer 40 feet wide.
- **Church Creek / Joergenson Slough.** This alternative was designed to provide flood control as well as improve fish and wildlife use at the site by planting a buffer. A riparian buffer would be planted on both sides of 6,000 feet of creek (25 feet each side) to provide shading, recruitment of woody debris, and habitat complexity. In addition, new fish-friendly tide gates would replace the existing ones. The flood benefits would be obtained from allowing agricultural lands to be fully utilized and increasing flood flow through Church Creek.

This study was primarily aimed at improving fish and wildlife habitat, so the three flood reduction alternatives were considered concurrently and a construction cost of $944,000 was estimated.

Stillaguamish River Section 205 Small Flood Study—1999

The Section 205 Small Flood Study (Section 205 Study) was pulled from the larger, Ecosystem Restoration Study in 1997. Snohomish County is the local sponsor for the Section 205 Study and the Corps of Engineers is the lead agency. The City of Stanwood

(City) and Stillaguamish Flood Control District are the primary partners and have committed financial resources to the effort. Other resource agencies, tribes, and special interest groups are part of the study team as well. The Section 205 Study is focused on reducing flood damages to the City and the surrounding area from both the Skagit River and the Stillaguamish River.

In early 2003, the local partners terminated the study agreement with the Corps due to funding issues. However, two alternatives were developed in the process and the local partners plan to pursue these alternatives outside of this study process.

Stillaguamish River Ecosystem Restoration Final Feasibility Report and Environmental Assessment – 2000

A feasibility report was the second phase of the Ecosystem Restoration Study. This report determined projects that effectively restored critical habitat throughout the Stillaguamish River basin. Specific objectives included restoring estuarine habitats, salmon spawning habitats, juvenile salmon rearing and refugia habitats, and rehabilitating degraded tributaries. As a result of this report, ten individual sites were selected in the preliminary National Ecosystem Restoration Plan. Implementation of some of these actions may provide flood relief as well.

Snohomish County, local tribes, the Corps, and others are currently continuing efforts to finance the restoration of the selected sites (Corps 2000).

Table 9: Previous Corps Flood Management Alternatives (1970s – 1980s).

Reference	Proposed Alternatives	Recommendation
CORPS 1975	1. Flood control reservoirs • Located at two upstream sites in the Stillaguamish 2. Levees • North of Stanwood to protect from Skagit River • South of Stanwood to protect from Stillaguamish	No action due to coordination with Skagit project
CORPS 1979a	1. Floodproofing 2. Flood control reservoirs • Located at two upstream sites in the Stillaguamish 3. Levee & channel alterations • Based on previous studies of the Stillaguamish 4. Levees • South of Stanwood to protect from Stillaguamish	No action taken.
CORPS 1980	1. Floodproofing 2. Levee Alternative 3A • 2.8 mi levee surrounding Stanwood to protect from both Skagit and Stillaguamish • Detention ponds for east Stanwood runoff • Irvine Slough pump station improvements 3. Levee Alternative 3B • 3.2 mi ring levee surrounding Stanwood • Detention ponds for east Stanwood runoff • Irvine Slough pump station improvements 4. Levee Alternative 3C • 2.8 mi ring levee surrounding Stanwood • Drainage channel along SR 532 • Irvine Slough pump station improvements 5. Levee Alternative 3D • 4.1 mi ring levee surrounding Stanwood • Detention ponds for east Stanwood runoff • Irvine Slough pump station improvements	No action taken.
CORPS 1989	1. Levee and related changes • 4.2 mi levee surrounding Stanwood • Irvine Slough pump station improvements • Roadway modifications to raise elevation • Gate and sandbag closures at railroad crossings	Levee and related changes recommended. No action taken.

6.1.1 FLOOD INSURANCE AND DISASTER STUDIES

In addition to the flood management studies conducted by the Corps throughout this period, several other studies and actions related to flood management of the Stillaguamish River were undertaken. These studies either made no attempt to analyze alternative flood management approaches or made primarily nonstructural recommendations to help reduce future flood damage.

Flood Insurance Study, Unincorporated Snohomish County—1983

As a result of the National Flood Insurance Act of 1968 and the National Disaster Protection Act of 1973, flood insurance studies were conducted for Snohomish County. In June 1971, the Corps conducted the first flood insurance study of Stanwood for the Federal Insurance Administration (Corps Apr. 1, 1977). The 100-year flood elevation near the central part of Stanwood was predicted from this study to be approximately 10 feet (NGVD29). The study was then updated during the late 1970s, and the results published by FEMA in 1983, the same year the Snohomish County flood insurance study was published. While some revisions have occurred since then, the flood maps for the major river systems in Snohomish County, including the Stillaguamish River, remain outdated.

According to the flood insurance study, the base flood elevation at Stanwood is 9.5 feet {National Geodetic Vertical Datum (NGVD)29}, rounded off to 10 feet (NGVD29) for flood insurance purposes. This flood level was determined by modeling the effects of a 100-year tidal event in Port Susan, combined with a 2-year flow event in the Stillaguamish River. This model was compared to one that used a 100-year flow event with a 2-year tidal event. The flood levels from the 100-year tide event/2-year flood event resulted in higher water surface elevations and therefore, were used to determine base flood elevations.

Other Participating NFIP Communities

TOWN OF DARRINGTON

The Town has participated in the National Flood Insurance Program (NFIP) for over 20 years, as some of Town is located on the Sauk River floodplain. Darrington has developed Flood Hazard Protection Regulations, Chapter 15.32, that provide for development and flood hazard reduction provisions.

CITY OF GRANITE FALLS

On May 4, 2001, Granite Falls, located on the South Fork Stillaguamish River, applied to the NFIP. The City should become a participating community in the NFIP as soon as FEMA headquarters processes the application.

CITY OF ARLINGTON

The City of Arlington is located at the confluence of the North and South Forks of the Stillaguamish River. The City has participated in the NFIP since 1983 and is currently

updating its flood hazard and sensitive areas codes to incorporate the Washington State Model Flood Damage Prevention Ordinance and environmentally critical areas..

CITY OF STANWOOD

The City of Stanwood is located on the western edge of the mainstem Stillaguamish River. Like other cities in the Stillaguamish, Stanwood is a participating member of the NFIP.

Reconnaissance Report of November 24, 1990 Flood

Immediately following the Nov. 24, 1990 flood, the Corps documented specific details of the flood event. These details were summarized in *Flooding in Western Washington from 21 to 26 November 1990* (Corps 1990). This report reported daily precipitation volumes, peak river flows, crest elevations, estimated recurrence intervals, and estimated damage categories for major rivers throughout western Washington, including the Stillaguamish.

Hazard Mitigation Study of the State of Washington after the November 1990 Floods—1991

A team of federal, state, and local agencies conducted this study in response to the declaration of Snohomish County and three other counties as federal disaster areas on November 26, 1990. The purpose of the report, Hazard Mitigation Opportunities in the State of Washington, FEMA-883-DR-WA (Interagency Hazard Mitigation Team 1991), was to encourage hazard mitigation actions to reduce the potential for future flood losses. This study recommended both structural and nonstructural actions to reduce future flood damage in each of the four counties during similar flood events. Some recommendations were for specific river systems, such as the Snohomish and Nooksack Rivers, but most were general, and included the items below.

Flood Damage Report of Residence Near Stanwood—1991

A private party had a consulting firm conduct a report to determine the cause of damage to a residence directly south of Stanwood during the November 1990 flood events. This report, *Report on Cause of Flood Damage, Kish Residence Flood Damage, Stanwood Washington* (CCNW 1991), documented the sequence of events that led to flooding in this area from the Stillaguamish River during both flood events.

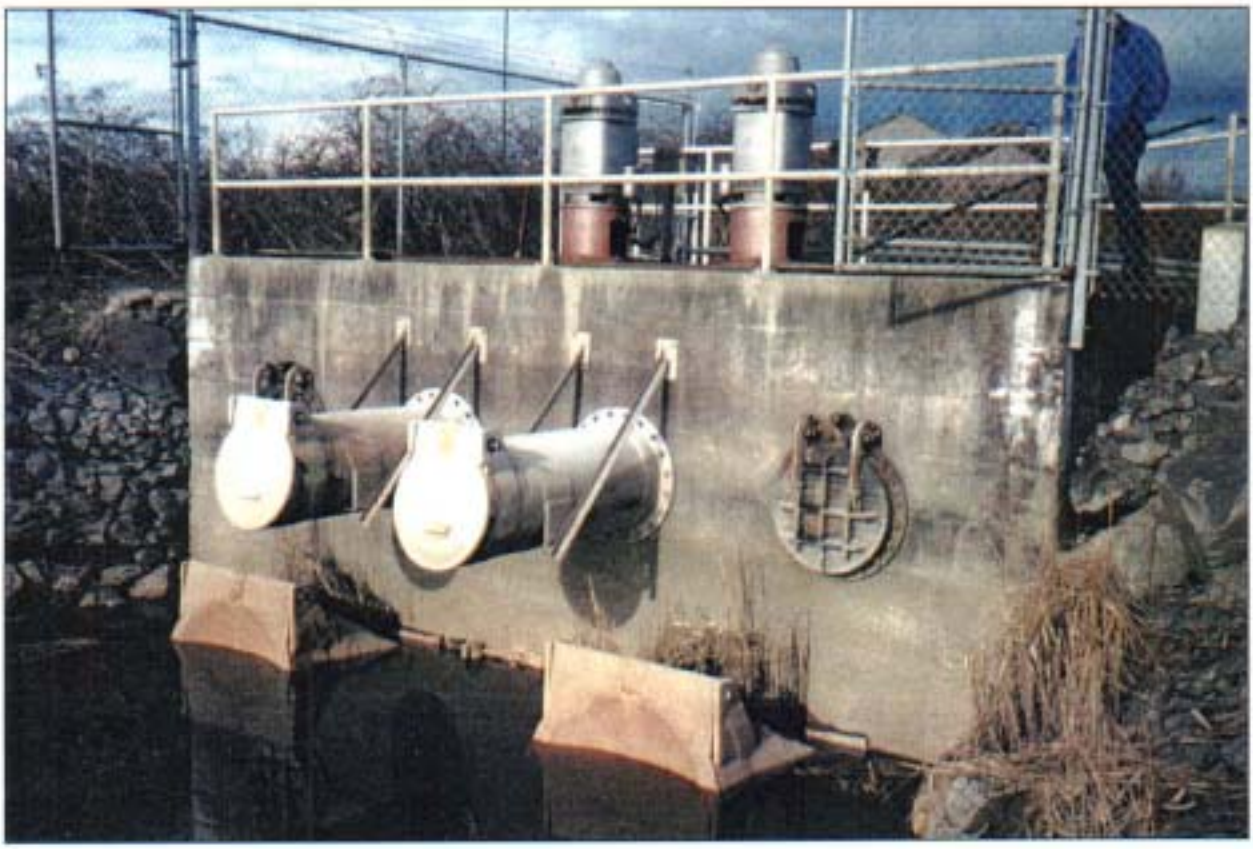
6.1.2 STANWOOD STORM DRAINAGE MASTER PLAN – 1972

In 1972, KCM, Inc., conducted a study of the drainage system in the Town (now the City) of Stanwood and developed a storm drain master plan for the town. In addition to proposed pipelines and detention facilities to control local runoff in the town, this plan (KCM 1972) recommended dredging Irvine Slough and constructing a pump station near the mouth of the slough to pump flow into the Stillaguamish River. This plan also recommended forming a drainage district with property owners along Joergenson Slough, the downstream reach of Church Creek, to improve levees along the slough and to better protect the town from flooding.

A pump station with less capacity than was recommended in the 1972 study was constructed in 1979, along with some minor dredging of Irvine Slough (Figure 25). While the pump station was designed to hold four pumps, only two 50-horsepower pumps were installed. At the same time, the levee at the mouth of Irvine Slough was removed since the pump station itself acted as a levee by preventing high water levels in the river from backing up into the slough.

After the wastewater treatment plant was constructed in 1962, alterations to the sewage lagoon dikes were proposed during the 1970s. In 1977, the City of Stanwood received partial funding from Ecology to improve these dikes (KCM 1987), but because the rest of the funding was never received, the alterations were never installed.

Figure 25: Pump Station at Mouth of Irvine Slough.



6.1.3 CITY OF STANWOOD WASTEWATER TREATMENT PLANT CAPACITY STUDY - 1987

In 1987, KCM conducted another study for the City analyzing the capacity of the treatment plant. As part of this study, they also analyzed ways to protect the lagoon from floods. To do this, this study recommended raising part of the dike around the lagoons by approximately 2 feet to an elevation of approximately 12 feet (NGVD29).

In November of 1990, the levees around the wastewater treatment plant lagoons were overtopped during both floods. The dikes surrounding the lagoons were raised and a dike/berm (a.k.a. Larson Dam) was constructed across Irvine Slough (Figure 26) to the northeast corner of the treatment plant. A 36-inch-diameter culvert was installed through the base of Larson Dam to carry flow in the slough (Figure 27). During flood events, Larson Dam restricts floodwater conveyance by preventing floodwater from entering the slough. Preventing floodwaters from entering the slough allows the City's stormwater drainage system, which is gravity fed, to continue to function without interruption.

Figure 26: Larson Dam Crossing Irvine Slough at the NE Corner of the WWTP.

Figure 27: Culvert Through Larson Dam for Stormwater Conveyance.

To help offset the restriction in flow through Irvine Slough, seven drainage culverts were installed in the Stillaguamish River levee at the southeast corner of the treatment plant to allow the area east of the sewage lagoons to drain more quickly once it has been flooded (Figure 28). Because these culverts were severely undersized (maximum flow capacity is 530 cfs), draining floodwater from the agricultural fields can take up to several days.

Figure 28: Aerial Photograph of the Seven Culverts at the SE Corner of the WWTP (1991).

6.1.4 STANWOOD HAZARD MITIGATION GRANT REQUEST - 1996

Following the February 1996 flood, the City of Stanwood applied for federal funding of a flood hazard reduction project on Irvine Slough under the Hazard Mitigation Grant Program. This project would have involved upgrading the pump station at the mouth of Irvine Slough to increase the capacity of the station, as well as installing a flow control structure and box culvert further upstream in the slough. These facilities would have reduced flood impact by improving the City's ability to lower water levels in Irvine Slough prior to a flood event, to increase the discharge rate from the slough into the Stillaguamish River, and to redirect flows from the slough to the river along the eastern side of the wastewater lagoons. The final application, submitted by the city to the Hazard Mitigation Program Administrator for the State of Washington in October 1996, was not approved.

6.2 Effects of Past Flood Management on Salmon Habitat and Other Environmental Values

The flood management techniques used since the 1800s have had a significant impact on salmon habitat. In the Puget Sound watershed, resident and *anadromous* fish species were listed as threatened under the federal Endangered Species Act (ESA). Because of these listings, additional studies have been undertaken to increase understanding of actions that reduce their survival rate and those that are catalysts to increasing their productivity.

Anadromous fish are those that migrate between freshwater and saltwater during their lifetime.

The purpose of this section is to provide the reader an overview of the benefits of flooding for fish and to document the primary factors in flood management that have negatively impacted them. This section is not intended to recreate the efforts of habitat specialists, biologists, and other experts working directly with salmon recovery. Readers are encouraged to review the materials referenced to obtain more specific information about salmonids (i.e., salmon and trout), their needs, and on-going recovery efforts.

6.2.0 HABITAT REQUIREMENTS

Unconstrained, aggrading floodplain reaches are highly productive habitats for salmonids (Stanford and Ward 1992). In addition, off-channel areas on floodplains of larger rivers have been shown to be important rearing habitats for salmonids during high winter flood events (Tschaplinski and Hartman 1983). Because of flood management methods used in the past (e.g., construction of dikes and levees), much of the habitat quantity and quality has been reduced or eliminated. Fragmentation of habitat and the resulting isolation of populations have affected the long-term viability of salmonid stocks.

Thomas et al. (1990) outlined several general principles to address habitat fragmentation and connectivity for the Northern Spotted Owl. These principles are equally applicable to salmonid recovery plans (Spence et al. 1996) and include:

- Large blocks of habitat are preferable to small blocks.
- Patches of habitat that are close together are superior to those that are far apart.
- Contiguous blocks are preferable to fragmented habitats.
- Interconnected patches are better than isolated habitat patches and corridors linking habitats function better when they resemble the preferred habitat of the target species.

Fish must be able to survive throughout the continuous path of its adult migration, spawning, incubation, emergence, rearing, smoltification, and ocean growth, with high quality habitat required in each life history stage and in the geographic corridors that connect the favored habitats.

Hayman et al. (1996) found that juvenile chinook salmon that rear in freshwater locations prefer backwater and natural bank habitat, compared to bar habitat and modified bank habitat (e.g. levees, rip-rap). Cover appears to be an important element in rearing habitat used by chinook salmon. Cover can be defined as depth, turbulence, large substrate, overhanging vegetation, undercut banks, woody debris, floating debris, and aquatic vegetation. The number of juvenile chinook salmon remaining in pools increases with increasing amounts of cover (Bjornn and Reiser 1991). Brusven et al. (1986) found that 82% of chinook less than a year old preferred stream sections with one-third overhead cover to sections without cover. The addition of cover increases the complexity of habitat and its carrying capacity.

6.2.1 HABITAT BENEFITS OF FLOODING

Natural river systems meander and change shape in part due to natural sediment inputs, large woody debris (LWD) recruitment, and flooding. This reshaping of the river and surrounding area is a necessary part of supporting the aquatic and terrestrial environments. This natural process increases the complexity of the system and contributes to the principles established above.

Flooding benefits habitat by providing clean gravel for spawning fish and recharging floodplain aquifers (Spence et al. 1996). Smaller floods occur more often and tend to dominate the channel forming characteristics of a river. Large floods, such as a 100-year flood event, can result in more significant channel changes such as reopening former meander channels. Trees from forested areas along the river either fall or are "recruited" into the river during flood events. As this LWD stacks up in the river, it slows the velocity of the flow, and creates pools where fish can regain energy, hide from predators, and feed.

6.2.2 SOME FACTORS THAT IMPACT HABITAT

Factors that restrict the production of salmonids at varying stages of their lifecycle in the watershed are called limiting factors. While much is still to be learned, it is understood that the construction of flood control structures (e.g., dikes or levees), channel filling, cutting off channels, channelization (i.e., straightening of the river), and the draining or filling of ponds has placed significant constraints on salmon and trout growth survival and reproduction.

A number of studies completed in recent years identify existing habitat conditions and limiting factors to production of fish. The cumulative information gained from these studies shows that the Stillaguamish River basin has suffered significant decline in the quantity and quality of fish habitat as a result of timber harvest, agricultural and urban development, and irrigation and flood control facilities (STAG 2000, WSCC 1999, Pess et al. 1999, and Collins 1994).

The lower mainstem reaches and associated floodplain show the most dramatic alterations. The fundamentally dynamic nature of the mainstem Stillaguamish River has been severely altered by levees or rock revetments leading to simplification of the system. The trends

suggest a continuing decline of habitat and fish populations unless restorative action is taken (Corps 2000) throughout the entire system.

Dikes/Levees

Flood control structures, such as dikes, levees, or bank revetments (i.e., riprap armoring), are a limiting factor to fish production. These structures limit channel and floodplain response to the delivery and routing of water, sediment, and large woody debris. The degradation and loss of normal channel conditions, floodplain interaction, and riparian functions were identified as contributing factors to the decline of salmonid populations in the Pacific Northwest. Several studies have examined the impacts from such modifications in other watersheds within Snohomish County (SBSRTC 1999, Pentec and NW GIS 1998, SEWIP 1995) in addition to the Stillaguamish (Collins 1997, Pess et al. 1999, Corps 2000).

Flood control activities that dominated from 1930 to present precipitated the loss of more than one-third of the mainstem channel area from 1933 through 1991 (Collins 1997). This reduction in channel area resulted from channelization, bank protection, levee and dike construction, railroad grade construction, and channel filling that effectively shortened and narrowed channels within the floodplain.

Corps' records from 1955 to 1965 show over 33 miles of riprap armoring basin wide, with the majority of these structures on the mainstem. Hayman et al. (1996) found an 85% reduction in growth and yield of juvenile chinook salmon due to riprapped banks compared to natural bank conditions.

Development

Agricultural and urban development converted many emergent and forested wetlands into agricultural, residential, commercial, and industrial uses by the placement of fill, building dikes and levees, and the construction of drains, ditches and other methods to remove or lower surface and ground water. It is difficult to estimate the extent of total wetland loss and/or conversion in the Stillaguamish Basin, but a study of the Snohomish estuary (Haas and Collins 2001) showed an 85% loss of estuarine wetlands.

Reclamation of tidelands resulted in constricted channels, cut off sloughs, and increased gradation of the delta. Two-thirds of currently existing reclamation occurred between 1870 and 1886. Removal of log-raft jams throughout the mainstem of the river destabilized channel banks and bed by locally increasing gradients and velocities and contributing to channel bed degradation. This also led to release of large quantities of stored sediment, eventually contributed to the disconnection of channel and floodplain as main channel bed degraded. The majority of jams were removed between 1877 and 1893.

> ***Reclamation*** is a process designed to adapt a wild or natural resource to serve a utilitarian human purpose. It is often used to refer to processes that destroy native ecosystems and convert them to agricultural or urban uses.

Landslides

Landslides have increased in rate and volume due to logging (Collins 1997). Landslides in small tributary channels can scour the tributary deeply, which can increase the velocity of future flows. These higher velocities have more erosive power and, in combination with landslide deposits in channels and near-channel areas, can lead to greatly increased sediment delivery and bank instability in the larger streams/rivers.

Landslides that deposit into larger tributaries or the forks can dam the streams/rivers leading to the buildup of a pond. Eventual failure or over-topping of the "dam" can lead to a catastrophic flow event that is greater than that expected from precipitation alone. Approximately 73% of the number of landslides are associated with clearcuts or forest roads, while 98% of the volume of landslides are so associated (Collins 1997).

Gravel Removal

Gravel removal from the river bed may contribute to the disconnection of side-channel sloughs from the main channel or of the floodplain from the main channel by deepening the channel. The elimination of these connections can reduce the potential for restoration and maintenance of floodplain wetlands. Gravel removal can also lower the local groundwater table, which potentially reduces summer base flows in the channel and/or reduces recharge to side channels and sloughs.

Stability of banks and beds can also be reduced dramatically when gravel is mined from the river leading to increased sediment delivery. Wider and shallower channels are created as opposed to naturally narrower and deeper. These changes contribute to higher summer stream temperatures and lower dissolved oxygen levels. The Stillaguamish River is listed as an impaired waterbody for both temperature and dissolved oxygen, among other parameters, on Washington's 1998 Clean Water Act 303(d) list (Thornburg and Williams 2000).

6.2.3 CHANGES IN FLOOD PLANNING

Each alternative developed in the Stilly Flood Plan seeks to incorporate habitat needs of fish and to reduce the negative effects of past flood management methods where possible. Alternatives that reduce the historic and prevent future adverse natural resource impacts are preferred. Also, alternatives that encourage natural floodplain processes, such as reestablishing natural storage areas or conveyance channels, were prioritized.

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CHAPTER 7

ALTERNATIVES AND RECOMMENDED ACTIONS

CHAPTER 7 – ALTERNATIVES AND RECOMMENDED ACTIONS

This chapter presents alternatives and recommended actions (RA) addressing the various hazards and hazard mitigation opportunities identified through completion of issue papers and committee meetings. To provide consistent evaluation of alternative actions, each hazard issue or mitigation opportunity is documented followed by recommended actions.

None of the recommended actions impact navigable waters of the Stillaguamish River, which are from the mouth of the Old Stillaguamish River channel (that which flows into Port Susan) to the confluence of Hatt Slough (approximately eight river miles) and from the mouth of Hatt Slough upstream eight river miles. In addition, potential impacts to natural resource losses will be determined when specific actions are implemented, and the appropriate federal, state, and local reviews will be completed. At that time mitigation measures, if required, will be identified.

The reader also is encouraged to refer to Appendix C, which provides detail about the hazards and mitigation opportunities. In addition, the locations of specific recommended actions are provided in Appendix G.

7.0 Evaluating Alternatives and Selecting A Recommended Action

7.0.1 PLAN GOALS AND OBJECTIVES

The Stilly Flood Plan Advisory Committee established goals and objectives in the beginning of this planning process. Ecology goals were expanded in the Stilly Flood Plan not only to incorporate the need to prevent loss of life but to protect the natural river processes (Table 10).

Table 10: Goals and Objectives of the Stilly Flood Plan.

1. Save lives and reduce public exposure to risk.	1.1. Prevent development in high hazard areas (i.e., areas where deep, fast flowing waters, large debris, rapid bank erosion, or channel migration that may threaten life, health, or safety.) 1.2. Improve flood warning and emergency response. 1.3. Ensure that risks associated with development in non-high hazard areas are minimized.
2. Reduce or prevent damage to public and private property.	2.1. Prevent development on the floodplain that would result in increased flood damage impacts to adjacent properties. 2.2. Minimize potential for damage to existing structures in non-high hazard areas. 2.3. Ensure that the benefits of maintaining existing flood control facilities outweigh the costs.
3. Reduce historic and prevent future adverse environmental or natural resource impacts of flood hazard solutions.	3.1 Ensure that flood hazard management is consistent with salmon conservation as defined under the federal ESA. 3.2 Ensure that the solution chosen to protect existing development protects or enhances riparian habitat, is the most cost-effective available, and is consistent with applicable land-use plans and regulations. 3.3 Incorporate new technology in the plan recommendations, as it becomes available (a process called adaptive management).
4. Reduce the costs associated with flood hazard and floodplain management.	4.1 Develop solutions that require little or no on-going maintenance (i.e., that are self-sustaining). 4.2 Improve coordination and consistency between county and other jurisdictions in floodplain management activities.
5. To the maximum extent possible, allow and encourage natural floodplain processes.	5.1 Pursue nonstructural solutions whenever feasible. 5.2 Re-establish natural storage areas or conveyance channels whenever feasible.

7.0.2 PRIORITIZATION CRITERIA

Flood hazard areas, mitigation opportunities, and other issues throughout the Stillaguamish River basin were identified through a public process. Flood hazards were prioritized using the following criteria:

- ✓ Consequences of no action (i.e., threats to public safety, damage to public infrastructure and property, and damage to private property);
- ✓ Urgency (how quickly is response required and does no action exacerbate the problem);
- ✓ Responsibility (is this a County responsibility), and,
- ✓ Opportunity (e.g., joint funding potential).

Flood hazard mitigation opportunities were prioritized using the following criteria:

- ✓ Potential for flood hazard mitigation (e.g., increased flood storage or flood conveyance); and,
- ✓ Habitat improvement potential (potential to improve habitat conditions while improving flood reduction objectives).

7.0.3 ALTERNATIVE ACTION EVALUATION CRITERIA

Once specific hazard areas and opportunities for flood storage or conveyance were identified, alternative actions for each were analyzed using the following evaluation criteria to identify a preferred action:

- ✓ Safety Risks: The effect of an alternative action on public safety and health should be evaluated both upstream and downstream of the site. If life and limb are currently endangered, the alternative action should have a beneficial impact on public health and safety to receive positive consideration. If there is currently no risk to life or bodily harm, the alternative action should not increase that risk.

- ✓ Environmental Impacts: The environmental impacts of an alternative action, including its effect on fish and wildlife habitat, wetlands, water quality, and other resources, should be evaluated both upstream and downstream of the alternative action site. The net environmental impacts of a alternative action (plus any mitigation measures) over the long term should be beneficial or insignificant.

- ✓ Technical Feasibility: The engineering and technical merits of a alternative action or alternative should be evaluated, and those alternative actions that are not feasible should be dropped.

- ✓ Benefit and/or Cost: Benefits should be measured as the effect on flood damages over the entire river system; costs should be measured as public and private costs for implementing and maintaining the alternative action over the long term.

  Benefits may also include non-quantifiable societal benefits that protect or enhance assets that are beneficial to society such as recreational opportunities, cultural areas, or historical areas. For a alternative action to receive approval, flood damage reduction benefits over the entire river system should exceed long-term costs.

  In the RA analysis that follows, only costs could be quantified in some cases while in others only the benefits could be quantified. In some cases, both costs and benefits were known. Once actions are implemented, this criterion can be better quantified.

- ✓ Consistency with applicable land use plans and regulations: The alternative action should be consistent with land use plans and federal, state, and local regulations governing activities in the floodplain and riparian corridor. As required by WAC 173.145.040(1)(g), a description of regulations that apply within the watershed is provided in Appendix D.

  Examples of possible applicable County and city land use plans and regulations include the General Policy Plan (GPP) and land use maps, critical areas (Snohomish County Code Title 30.62, City of Stanwood Title 17.125, City of Arlington Title 20.88), flood hazard (SCC Title 30.65, COS Title 17.120, COA Title 20.64), and shoreline (SCC Title 30.44, Stanwood and Arlington Shoreline Master Programs) regulations.

7.1 Basin-Wide Alternatives and Recommended Actions

The actions in this section address basin-wide issues.

FEMA Flood Insurance Re-Study

Issue

The existing County FEMA flood maps are outdated and contain known errors that may allow development in locations and at elevations that put the structure at risk of damage.

Discussion

The County uses FEMA flood maps that were completed in the late 1970s to early 1980s to determine allowable locations and minimum elevations for new floodplain construction. Because of changes in the basin over the last 25 years, these maps do not adequately assess the flood risk in many areas. For instance, near Stanwood new modeling indicates 100-year flood levels are three feet higher than those shown on the FEMA maps. There are also areas mapped as being out of the 100-yr floodplain, and therefore exempt from flood hazard code requirements, which are known to flood in far smaller events. Ensuring that structures are built to elevations above inundation levels and that the 100- and 500-year floodplains are accurately mapped is important in protecting lives and property.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Unknown. Currently homes can be constructed in areas where the true flood risk in not accurately assessed.
   b. Environmental Impacts: Unknown. If homes or businesses are built in the floodplain without adequate protection, floods may result in the release of household or commercial toxins during flooding.
   c. Technical Feasibility: NA
   d. Benefit and/or Cost: NA
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Collect and use high water marks to set elevation standards where maps are known to be inaccurate.
   a. Safety Risks: None.
   b. Environmental Impacts: None.
   c. Technical Feasibility: Feasible. However, it is unlikely that High Water Marks could be collected throughout the entire river system in a way that ensured all mapping errors were detected.

d. Benefit and/or Cost: The County typically spends several thousand dollars in staff time after large floods to collect high water marks. To maximize the effectiveness of this alternative, high water marks could be collected routinely on all major floodplains, modeled, and incorporated into a Geographic Information System (GIS) database for use in regulatory decisions. Annualized costs are estimated to be between $2,000-$4,000/yr. Since 1978, 526 claims have been paid totaling almost $6.8 million dollars in Snohomish County (FEMA 2001).

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

3. Conduct a Flood Insurance Re-Study (RFIS).

a. Safety Risks: None.

b. Environmental Impacts: None. If future site-specific actions are identified as a result of the RFIS, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

c. Technical Feasibility: Feasible.

d. Benefit and/or Cost: Costs for flood mapping can range up to $8,000 per river mile. It would likely cost $200,000-$300,000 to fully re-map the Stillaguamish River floodplain. Opportunities exist for the County to partner with FEMA to update the Flood Insurance Rate Maps (FIRM). In some cases, funding can be up to 100% of eligible costs, which can include digital mapping (excluding base map), hydrology and hydraulics modeling, and re-delineation of Flood Hazard Areas.

Average flood insurance claims for inundation damage will generally exceed $12,000 per flood, so it is estimated that if new mapping prevented damage in 20-30 new or rebuilt homes the benefits would meet or exceed the costs. When completed, the mapping and modeling required for this alternative would also be used to develop several other recommended actions in this plan. Some of these include flood control structure updates (*RECOMMENDED ACTION 4*), public lands analysis (*RECOMMENDED ACTION 5*), and mapping of high hazard areas (*RECOMMENDED ACTION 11*).

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 1: CONDUCT A FLOOD INSURANCE RE-STUDY.

Conduct a Flood Insurance Re-Study for the Stillaguamish River basin and pursue federal or state cost-sharing.

ELEVATION/RELOCATION PROGRAM

Issue

A number of existing residential structures and critical facilities are at risk for flood damages because they were constructed at low elevations or in hazardous locations. While solid technical information and established regulations help to protect new development from these risks, existing risk must still be addressed.

Discussion

Basin-wide flood modeling is expected to yield similar results to those found in modeling some portions of the lower mainstem of the Stillaguamish River. Results of hydraulic modeling conducted as part of the Corps-led Section 205 Small Flood Study in the lower basin yielded higher water surface elevations than in current regulatory levels. This implies that the true flood risk to residential and nonresidential structures on the floodplain is most likely greater than represented by current flood regulations. Current County regulations require that the lowest floor of residential structures be elevated a minimum of one foot above the 100-year flood level (base flood). Critical facilities (e.g., schools, nursing homes, hospitals, police, fire, etc) are required to construct the lowest floor elevation three feet above base flood levels.

The critical facilities currently located on the mainstem floodplain are shown in Figure 29. Most of the facilities are located in the City of Stanwood including the City of Stanwood Fire Department, elementary and middle schools, the Josephine Sunset Home (350+ elderly residents and staff), and two medical facilities.

The City of Stanwood Fire Department has secured a bond to relocate the fire station to upland property by 2003, but the relocation will cost more than the funds secured through the bond. Both medical facilities (one is currently being constructed) are built on fill. Both schools and the Josephine Sunset Home have no plans to relocate or elevate. These critical facilities are self-contained and are included in the fire departments priority evacuation sites. Implementation of the Corps-led Section 205 Flood Study (Page 74) will significantly reduce the risk to all critical facilities inside the City by providing protection to the city from the Skagit and Stillaguamish river systems.

Only two other critical facilities were identified outside of the City of Stanwood on the floodplain. They include the Silvana Fire Station No. 1 (1430 Pioneer Hwy) and Fire Station No. 2 (21207 27th Avenue NE) just east of I-5. Fire State No. 1 is located in Silvana, which has been inundated up to three feet deep during even small flood events. Residents passed a $1.2 million bond to fund the relocation of the Silvana Fire Station to 212th and Happy Valley Road (outside of the floodplain), but this amount is an estimated $400,000 to $500,000 short of the relocation cost. Fire Station No.2 has been flooded once (in 1990) and relocation of this facility is planned to take place within the next five to ten years. No funding has been secured for this relocation.

In addition to the critical facilities, there are many existing homes on the floodplain or in high hazard zones (e.g., Chatham Acres – *RECOMMENDED ACTION 20*) that will continue to flood during relatively small, frequent floods.

After the County was declared a federal disaster area following the October 2003 floods, federal funds were released to the state so that affected jurisdictions could apply for and obtain funding assistance to address natural hazards. Because this action was identified in the plan, a Letter of Intent was submitted in December 2003 to the state requesting support to implement this action.

Evaluation of Alternative Actions

Critical Facilities

1. No Action. Allow critical facilities in the floodplain to continue to be exposed to periodic flooding risking potential disconnection in services due to flooding.
   a. Safety Risks: Unknown. The loss of fire station functionality during floods could impact both floodplain and upland residents.
   b. Environmental Impacts: Unknown.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Unknown. Should a major flood occur, fire stations on the floodplain may be prevented from providing emergency services.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. Currently no plans or regulations direct this action.

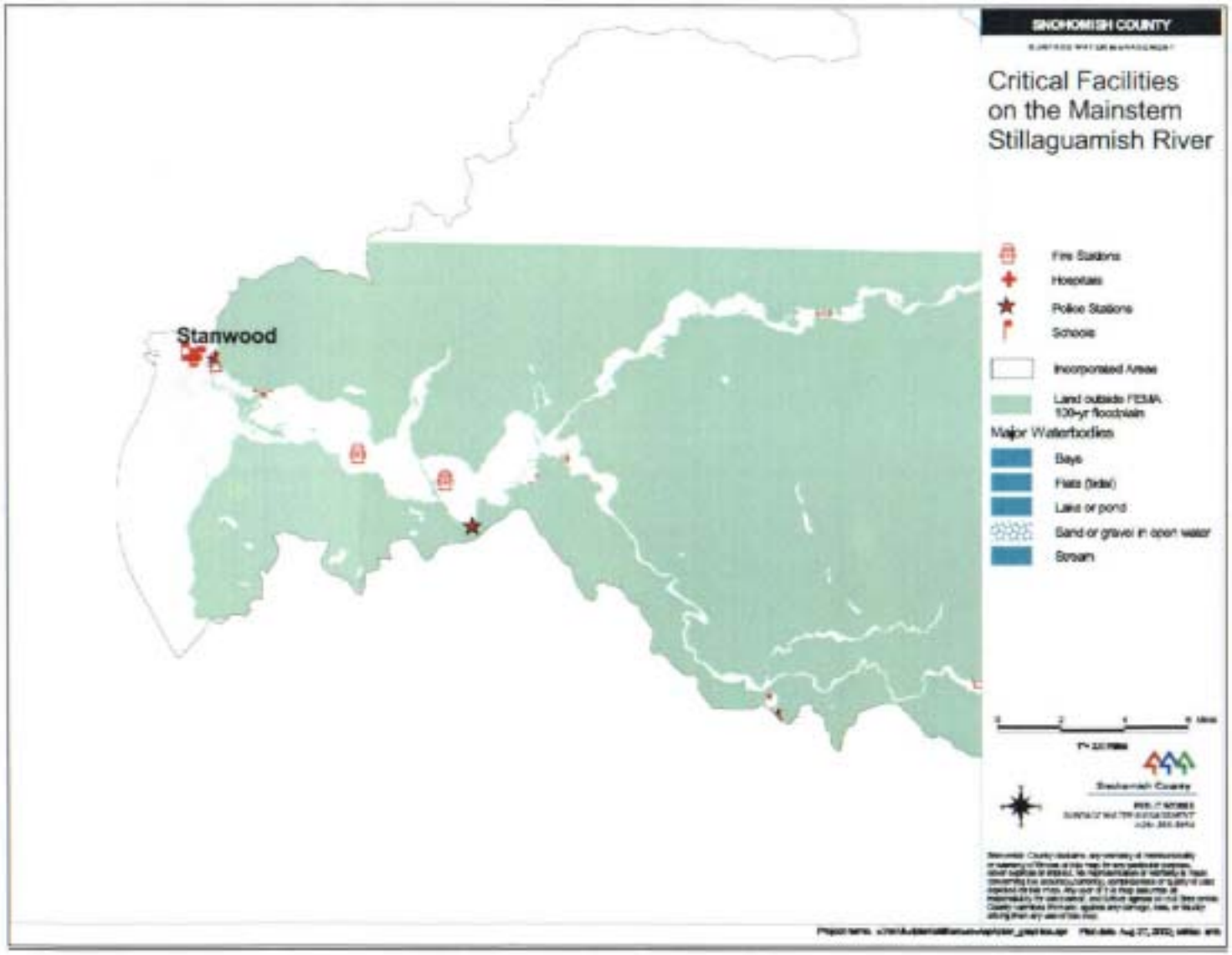
2. Relocate critical facilities with federal or state funding assistance.
   a. Safety Risks: None.
   b. Environmental Impacts: None. If the critical facility relocation process results in potential environmental impacts, mitigation measures will be identified and addressed through appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Two of the three fire stations currently located on the floodplain have secured most of the funding to complete the planned moves. Each station anticipates an additional $500,000 to complete the move and to ensure the most up-to-date equipment is provided to firefighters.

      Relocation of the Stanwood Fire Station, Silvana Fire Station No. 1, and Fire Station No. 2 would provide a permanent solution to flood damage and provide added assurances that these facilities would remain operational during an emergency. Should additional critical facilities, such as the Josephine Sunset Home, choose to relocate at some time in the future, this action would provide a mechanism for funding assistance through the FCAAP program, Hazard Mitigation Grant Program, or other resources.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 2: RELOCATE CRITICAL FACILITIES.

Relocate critical facilities with the priority being given to the three fire stations.

Figure 29: Critical Facilities on the Mainstem Stillaguamish River.



Residential Structures

1. No Action. Allow existing residential structures that are not above the 100-year flood elevation or outside the high hazard zones to be periodically damaged.
   a. Safety Risks: Unknown. There are likely homes built in high erosion hazard zones where lives may be at risk during flood events.
   b. Environmental Impacts: Unknown. If homes are built in the floodplain without adequate protection, floods may result in the release of household or commercial toxins during flooding.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Unknown. Should a major flood occur, fire stations on the floodplain may be prevented from providing emergency services.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. Currently no plans or regulations direct this action.

2. Develop and implement an elevation/relocation program to assist private property owners to elevate residential and nonresidential structures above base flood levels or relocate them outside the floodplain or high hazard zone.
   a. Safety Risks: None.
   b. Environmental Impacts: None. If future site-specific actions are identified as a result of this program, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. This program would provide the necessary funding assistance to residents to elevate or relocate their homes and more residential structures will require elevation or relocation assistance once the RFIS (*RECOMMENDED ACTION 1*) is completed and the rate maps are updated.
   d. Benefit and/or Cost: Elevating or relocating structures would reduce or prevent future flood damage costs. Elevation of a home typically costs around $30,000-$50,000. Acquisition/relocations were estimated between $100,000-$200,000 per property as it would entail acquiring the home and property from the owner who purchases a new house independently. Benefit/cost ratio for individual properties must be greater than one.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 3: ESTABLISH A VOLUNTARY ELEVATION/RELOCATION PROGRAM.

Establish an elevation/relocation program that provides funding assistance to property owners who voluntarily opt to elevate or relocate their residential structures. Identified properties could then be prioritized for implementation and potential funding sources (e.g., hazard funds) could more easily be taken advantage of.

EXISTING COUNTY FLOOD CONTROL STRUCTURES

Existing Snohomish County flood control structures in the Stillaguamish River basin include the following:

North Fork Stillaguamish River:

1. Oso Levee on the right bank (County has a formal agreement with the Corps to maintain);
2. Bridge 89 Dike (constructed in County right-of-way).

South Fork Stillaguamish River:

1. Robe Hill Dike (County has a formal agreement with the Corps to maintain);

Mainstem

1. Dike Road Dike (Corps dike, but maintenance of berm and road Snohomish County responsibility);
2. Town Tavern Road Dike (Corps dike, but maintenance of berm and road Snohomish County responsibility).

More information on each of these structures can be found in Issue Paper #2, Appendix C.

Issue

County flood control structures in the Stillaguamish River basin are generally in good condition according to visual inspections conducted by Snohomish County staff (Appendix C). However, it is unclear how most of these structures were constructed or how they have been maintained, the level of protection provided by the structures is generally not known, and in some cases, it is unclear what the structure is designed to protect. Modifying structures (e.g., raising, lowering, breaching) or leaving them in their current condition cannot be addressed without ascertaining the construction methods used, the intended purpose of each structure (e.g., level of protection), and whether each structure is still achieving that purpose.

Discussion

The County now owns a system of flood control structures where the integrity of the structures, the level of protection, and the flood damage reduction benefits are not fully known. It is likely that some of these structures could be modified to enhance their effectiveness or reduce their environmental impact. Some of the structures appear to be no longer providing flood damage reduction benefits. To determine the best course of action, more information is needed on the structures.

Evaluation of Alternative Actions

1. No Action. The County continues to maintain structures as it currently does, repairing them as needed after floods.

   a. Safety Risks: Unknown. Because of the uncertainty of the level of protection provided by a structure or of its structural integrity, flood protection and the ability to provide adequate warning are uncertain.

   b. Environmental Impacts: Varies. These structures alter habitat and reduce the floodplain connectivity, river meander potential, and habitat function. No action will result in continued negative impacts to the habitat.

   c. Technical Feasibility: NA

   d. Benefit and/or Cost: In some cases there are records of costs incurred in maintaining and repairing the structures. Documentation of the benefits of the structures has not usually been done. Costs will continue to be incurred on the structures under the no action alternative.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. Currently no plans or regulations direct this action.

2. Conduct a detailed structure inventory to determine construction method, level of protection, and benefits provided by each County structure and implement results.

   a. Safety Risks: None.

   b. Environmental Impacts: None. If future site-specific actions are identified as a result of this dike assessment inventory, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

   c. Technical Feasibility: Feasible. Identify those structures that are no longer performing their original function and determine continued County ownership of such structures. Recommend structure modification, continued maintenance or abandonment based on results of inventory.

   d. Benefit and/or Cost: $50,000 for the structure analysis. Hydraulic analyses completed as part of the Flood Insurance Study can be used to complete this task. Additional, site-specific work may be required including, but not limited to conducting an engineering analysis for each structure, documenting past, present, and future channel changes, and completing other information as relevant. The goal of the analysis is to ensure that the benefits exceed the costs for all structures the County maintains.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 4: ANALYZE ALL COUNTY-OWNED OR MAINTAINED FLOOD CONTROL STRUCTURES.

Conduct a flood control structure analysis of County-owned (either partial or full County ownership) structures in the basin to determine design parameters, construction methods, current structural condition, habitat restoration potential, and other parameters as identified. Include recommendations for future County actions.

PUBLIC LANDS

Issue

Snohomish County Parks (and other government agencies) own significant areas on the floodplain of the Stillaguamish River. Although none of the parks in the floodplain contain flood control structures that completely prevent inundation, some contain flow obstructions. Modification of these obstructions, or excavation of additional storage areas, may increase the flood storage or conveyance capacity sufficiently to reduce flood damages nearby and downstream.

Discussion

Increasing the flood storage or conveyance opportunities in the County parks system was investigated. Two parks on the north fork, Cicero and Cloverdale, have the greatest potential to be altered to increase flood storage. The Whitehorse Trail (WHT) runs through each park and acts as a barrier to floodwater. Determining the feasibility of expanding the flood storage capacity of these parks will require additional analyses. Other parks, including Squire, Twin Rivers, River Meadows, and Portage Creek Wildlife Reserve, may also offer some additional flood storage opportunity. In addition, lands owned by DNR or others may also have this opportunity.

The potential benefits of these actions can be in one of two categories. First, conveyance improvements allow the active channel and floodplain to convey more floodwaters at a given water level. By doing so, flood levels and velocities on nearby public and private properties can be reduced. Second, flood storage improvements can increase the volume of floodwaters temporarily stored and slowly released from a floodplain area. Increasing flood storage can attenuate peak flows and hence reduce damages downstream. While conveyance improvements are local and can be analyzed on a site-by-site basis, the potential increase in flood storage from any one public land site is not large enough to reduce downstream flooding. Therefore the cumulative effects of increased flood storage will have to be analyzed on a basin wide scale to see if flood damage reduction benefits can be realized.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: None.
   b. Environmental Impacts: None.
   c. Technical Feasibility: NA
   d. Benefit and/or Cost: NA
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

2. Investigate the potential to modify parks and other public lands to improve flood storage or conveyance.
   a. Safety Risks: None.
   b. Environmental Impacts: Low. Improving flood storage opportunities would open areas to inundation that have not been in the recent past. Modifications may offer the potential to improve habitat conditions. If park or public land modifications result in potential environmental impacts, necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: To evaluate the benefits of cumulative flood storage increase, a hydraulic model of the full river system must be developed, which would be completed as part of the update to the Flood Insurance Maps noted in *RECOMMENDED ACTION 1*. Sites identified as having cumulative or local flood damage reduction potential would have additional site-specific work required including engineering analyses and habitat assessments. The cost of this action is dependent on those results.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. This alternative meets the Comprehensive Parks Plan (2000) goal of promoting preservation of natural areas (environmental education, conservation of open space, public access).

RECOMMENDED ACTION 5: THE COUNTY SHOULD INVESTIGATE ENHANCING FLOOD STORAGE ON PUBLIC LANDS.

Conduct a study to investigate the potential to modify County parks and other public lands to improve flood storage or conveyance opportunities and implement findings.

PRIVATE PROPERTY- RIVER BANK EROSION ISSUES

Issue

The County's Cooperative Bank Stabilization Program (CBSP) is an effective tool to help residents with material costs associated with bank stabilization efforts. To continue to comply with critical area regulations, much higher costs are now associated with the permitting process needed to access those funds. The permit process and associated studies can make it cost-prohibitive for residents to take advantage of the assistance provided by the CBSP.

Discussion

Local, state, and federal permitting requirements for bank stabilization efforts can be extensive. Direction from federal agencies {National Marine Fisheries Service (NMFS), United States Fish &Wildlife (USF&W)} is also unclear as to what kind of bank stabilization methods, if any, are permissible. Costs to permit bank stabilization activities, whether private or public, have significantly increased as a result of the listing of chinook salmon and bull trout. Currently, the difficultly in obtaining permits means some hazards that could have been addressed in a cost-effective way are deferred until emergency action is needed during or immediately after a flood. Unfortunately at that point the options are often more expensive and environmentally damaging than those that could have been implemented prior to the emergency.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: None.
   b. Environmental Impacts: None.
   c. Technical Feasibility: NA
   d. Benefit and/or Cost: NA
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Review existing permitting requirements to determine ways in which the County may assist landowners in completing permitting and technical requirements where providing such assistance would provide a public benefit beyond protection of private property.
   a. Safety Risks: None.
   b. Environmental Impacts: None. If future site-specific actions are identified as a result of this program, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible.

d. Benefit and/or Cost: Unknown.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

3. Investigate use of streamlined Joint Aquatic Resource Permit Application (JARPA) - eligible projects (e.g. projects using woody debris).

   a. Safety Risks: None.

   b. Environmental Impacts: None.

   c. Technical Feasibility: Feasible.

   d. Benefit and/or Cost: Unknown.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. JARPA eligible projects, which must meet specific conditions, are exempt from specific federal, state, and local government permitting and fee requirements (ESHB 2879, Sections 1 and 2).

RECOMMENDED ACTION 6: ASSIST PUBLIC WITH PERMITTING REQUIREMENTS ASSOCIATED WITH COOPERATIVE BANK STABILIZATION PROGRAM

Review existing permitting requirements to determine ways in which the County may assist landowners in completing permitting and technical requirements associated with eligible bank stabilization efforts.

FOREST PRACTICES

Issue

Timber harvest and roading are the two primary forest practices that affect the volume and flow path of water reaching a stream. Because almost 75% of the entire Stillaguamish River basin (90% of the upper basin) is considered commercially harvestable forestland, and over a third of that forestland is in the rain-on-snow area, a preliminary evaluation was conducted on these practices to understand their potential impacts on flood peaks in the Stillaguamish River.

Discussion

Chapter 86.12 of the RCW indicates that "restrictions on land clearing activities and development practices that exacerbate flood problems by increasing the flow or accumulation of floodwaters" should be an element of any comprehensive flood plan. It also explicitly states that land clearing activities do not include forest practices as defined in Chapter 76.09 RCW ("Forest practice" means any activity conducted on or directly pertaining to forest land and relating to growing, harvesting, or processing timber...). However, the state guidelines used to develop this flood plan state that addressing forest practices and their potential impact on flood hazard management planning is required (Ecology 1991). *RECOMMENDED ACTION 7* and *RECOMMENDED ACTION 8* are designed to fulfill that requirement.

Issue Paper #1 (Appendix B) describes forest practice impacts on basin hydrology and sediment loads, identifies ownership and land cover type by subbasin for each jurisdiction, and summarizes existing federal, state, and local forest practices regulations. Issue Paper #1 also identifies the need to fill data gaps, refine methodologies used to conduct watershed analyses in the basin, and address jurisdictional differences.

DATA GAPS

Continued improvement in scientific understanding and methodologies will lead to a greater certainty in determining the effects of forest practices on floods. Past studies conducted by different organizations have shown the critical need for data. The scarcity of gage data (e.g., flow, snowpack, and rainfall) in the Stillaguamish River basin hinders hydrologic and hydraulic analyses and limits understanding of the impacts of forest practices on the basin. In the Deer Creek Watershed Assessment Unit (WAU) on the North Fork, Washington State Department of Natural Resources cited lack of on-site flow gages on the Stillaguamish River that led to uncertainty in peak flow results determined in that assessment.

Existing LANDSAT satellite imagery combined with aerial photography provides a component of the baseline forestry data that can assist in flood damage reduction efforts. This information can be used to determine the different age classes of forests on private, state, and federal lands within the Stillaguamish River basin. These data can be used to determine how the new methods of managing Washington State forestlands impact the Stillaguamish River basin over time.

METHODOLOGIES

Methodologies used to conduct watershed analyses lack key hydrologic information. The hydrologic modeling component used in the WAU is a very important part of the watershed analyses conducted by DNR for specific subbasins. Although watershed analysis provides a very extensive examination of impacts of forest practices in a subbasin, it does not include surface water impacts from road development. Roads concentrate and direct flows enabling them to reach the main channel more quickly.

Hydrologic modeling can be used to better establish a relationship between basin-wide forest practices and flood flow frequencies, particularly those practices within the rain-on-snow area.

JURISDICTIONAL DIFFERENCES

Jurisdictions manage forestlands using separate methods and procedures as identified in the issue paper. A tremendous amount of time and effort went into developing the new plans and rules under which federal, state, and private forestland are managed and as a result, significant improvements to basin hydrology are expected in the future. Although state and private forestland owners have significantly altered management practices, clearcutting on all state and

private lands is still the primary method of timber harvest. Clearcutting on federal forestlands for the purposes of timber harvest is no longer permitted.

Although the watershed analyses conducted by DNR identifies cumulative effects of timber harvest within a subbasin, neither the Forest Practice Rules nor the Habitat Conservation Plan regulate the overall percentage of a subbasin that can be clearcut or exist in a hydrologically immature state at any one time. This presents a risk that multiple owners within a subbasin could cumulatively harvest to levels that increase flood peaks.

Evaluation of Alternative Actions

1. No Action. Analyses of forest practice impacts would continue as is currently done.
   a. Safety Risks: None.
   b. Environmental Impacts: Improved. Updates to forest practice regulations (WAC 222) may improve current conditions, but it is not known to what extent.
   c. Technical Feasibility: NA
   d. Benefit and/or Cost: NA
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

2. Conduct an additional hydrologic and hydraulic analysis of forest practices impacts on flood peaks.
   a. Safety Risks: None.
   b. Environmental Impacts: None. If future site-specific actions are identified as a result of these technical analyses, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. Additional gages may be required at selected sites throughout the basin to obtain required data.
   d. Benefit and/or Cost: Benefits are difficult to quantify, but additional data will help to reduce the uncertainties inherent in analyzing basin hydrology and land use impacts. Locating gages involves obtaining right-of-way easements and surveying. Once installed, on-going maintenance is required, typically requiring monthly visits to obtain associated data.
      i. Installation costs for gages range from around $3,000 to $10,000 for rain and stream gages. Annual operating and maintenance costs range from $500 per year for a rain gage to $2,000 per year for a river gage with flow. Rain gages cost approximately $500 for materials and two days staff time for installation. Radio telemetry provides real-time feedback so flood warning capability is enhanced.
      ii. Discharge or flow measurements are obtained by lowering a velocity meter on a sounding weight from a crane. The system can cost around $4,000.

iii. Staff gages are basically large rulers that have insignificant material costs, but take approximately two days to install.

iv. One snowpack gage (Miner's Ridge, Elevation 6,200 Feet) is currently maintained by the NRCS and data can be obtained from their web site (http://www.wrcc.dri.edu/snotel/snowash.html). A standard snowpack gage costs around $20,000 to purchase and install.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

3. Develop a study committee to address differences in methodologies, data gaps and associated needs, and to develop funding mechanisms.

   a. Safety Risks: None.

   b. Environmental Impacts: None. If future site-specific actions are identified as a result this committee's work, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

   c. Technical Feasibility: Feasible.

   d. Benefit and/or Cost: Unknown.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 7: CONDUCT ADDITIONAL HYDROLOGIC AND HYDRAULIC ANALYSIS OF FOREST PRACTICE IMPACTS ON PEAK FLOWS.

Conduct a comprehensive hydrologic and hydraulic study to determine the potential impacts of forest practices on peak flows in the Stillaguamish River basin. Identify additional gages required to meet long-term data collection needs. Document location, type (rain, snowpack, flow), and intent for each gage installation should be identified throughout the basin.

RECOMMENDED ACTION 8: ESTABLISH A STUDY COMMITTEE TO ADDRESS FOREST PRACTICES.

Establish a study committee consisting of local, state, and federal forestland representatives, government representatives, local residents, tribal representatives and others as appropriate to increase jurisdictional cooperation on a basin scale to reduce cumulative impacts from forest practices.

FLOODPLAIN LAND MANAGEMENT

Issue

Existing regulations were largely based on the Flood Insurance Study results of the early 1980s, which, as described earlier, are outdated. As a result, the regulations may not be providing the intended level of life protection, risk reduction, or property damage reduction.

Floodplain is the land area adjoining a river, stream, watercourse, ocean, bay or lake, which is likely to be flooded. The extent of the floodplain may vary with frequency of flooding being considered (SCC 30.91F.410).

Some of the Snohomish County regulations that may apply include the Unified Development Code, Title 30, contains the flood hazard management (SCC 30.65), critical areas (SCC 30.62), shoreline management (SCC 30.44), and environmental review regulations (SCC 30.61). In addition, Chapter 30.21, Zoning and Development Standards, also provides some guidance on floodplain development. Neither Stanwood nor Arlington has land on the floodplain where significant numbers of new structures would be allowed. However, their flood hazard codes are noted in the text that follows. Appendix D provides additional detail about the regulations for the cities of Stanwood and Arlington.

The ***Floodway Fringe*** means the portion of a floodplain that is inundated by floodwaters but is not within a defined floodway. Floodway fringes serve as temporary storage areas for floodwaters (SCC 30.91F.440).

One of the most significant issues that will influence the level of future flood damages in the Stillaguamish River basin is how much new development occurs on the *floodplain*. While the majority of the floodplain is zoned with minimum lot sizes of 5 and 10 acres, many undeveloped and potentially sub-dividable lots still exist on the floodplain.

Discussion

Floodway is the regular channel of a river, stream, or other watercourse, plus the adjacent land areas that must be reserved to discharge the base flood without cumulatively increasing the water surface elevation more than one foot (SCC 30.91F.430).

The current County flood hazard regulations (SCC Title 30) regulate development on the *floodplain* and use the standard FEMA zoning of *floodway* and *floodway fringe*. In addition, on the Stillaguamish River, the floodplain area downstream of the confluence of the Upper Stillaguamish River channel and Cook Slough (RM11.1) is designated as *density fringe*. City codes are similarly designated.

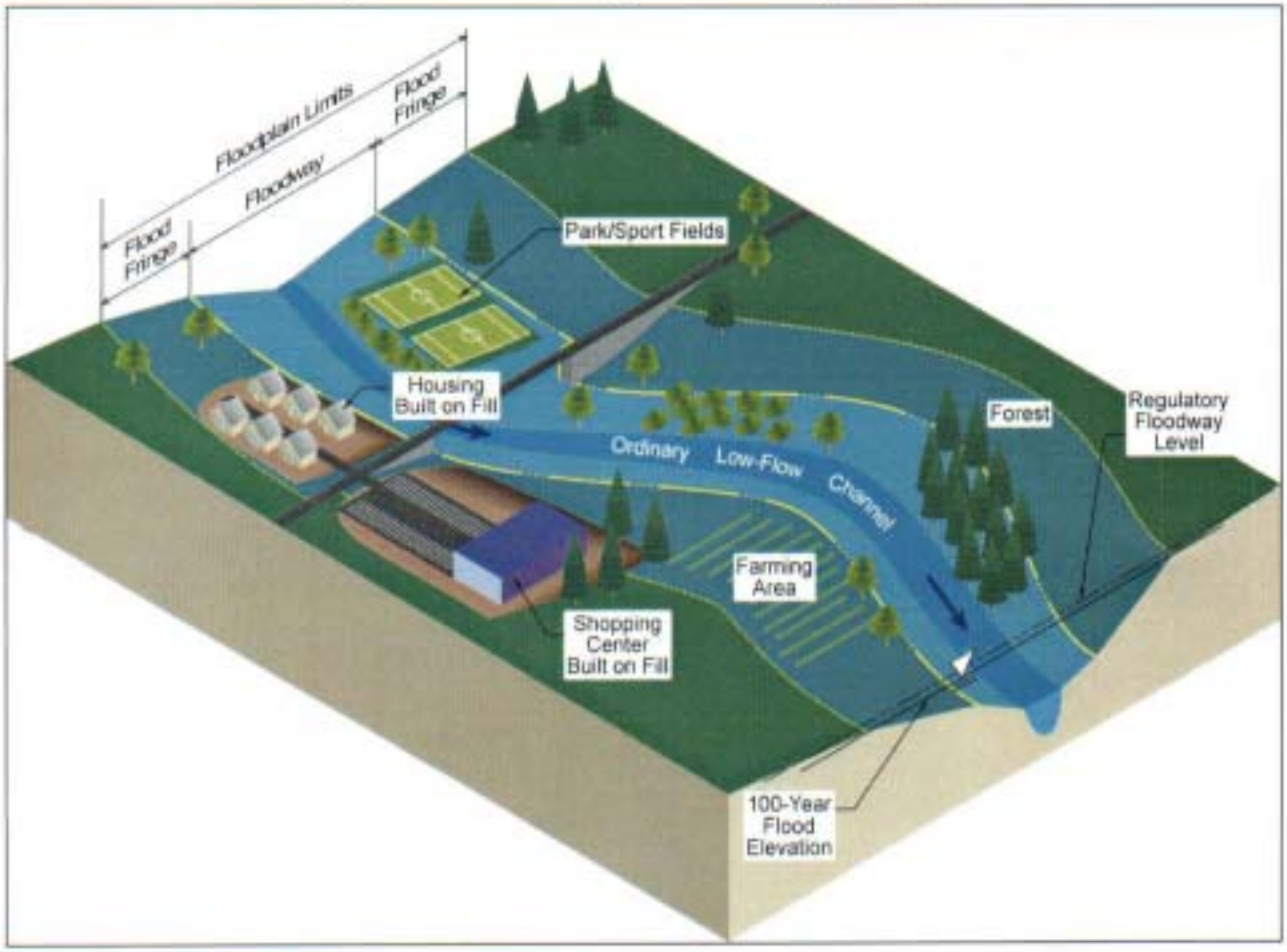
Density Fringe is that portion of the floodplain in the lower Stillaguamish River in which the floodway area cannot reasonably be established and in which development is regulated by maximum development density criteria (SCC 30.91D.100).

In both city and county regulations, no new residential construction is allowed in the floodway, and rebuilding of existing structures is also tightly controlled. The controls are intended to provide sufficient floodway area to convey a 100-year flood. In the floodway fringe development is allowed.

The majority of the mainstem Stillaguamish River floodplain is zoned for agriculture, with a minimum lot size of 10 acres. In the upper North and South forks the zoning is predominately Rural 5-acre. As part of meeting the state Growth Management Act requirements, the County developed a General Policy Plan in which Urban Growth Areas (UGA) are designated. Higher densities are focused in UGAs to facilitate efficient urban services.

As more homes are built on portions of the floodplain, flood damages can be expected to increase. As discussed earlier in this chapter, existing FEMA maps do not accurately assess the true flood risk, which means that new homes may be constructed at elevations that are lower than actual base flood levels. This is due to both changes in basin hydrology and simplifications in the old computer models used to develop the maps.

Figure 30: Flood Fringe and Floodway Zoning.



Even if the County accurately remaps the floodplain and adopts new regulations, such as zero rise or compensatory storage requirements (described below), flood damages are still expected to increase. Many of the existing floodplain residences were built years ago on the higher ground on the floodplain where the flood threat was less. New development will be forced into lower areas that may be subject to deeper, faster floodwaters in some cases. New roads and utilities serving the houses will be at risk for damage, inundation, or both. Some residents will inevitably have vehicles and other belongings flooded.

Potential Future Floodplain Development

To estimate the potential increase in floodplain development throughout the system, a land-use and zoning analysis was performed using data from the County's GIS datasets and Assessors 2001 database. The analysis was performed on all properties situated within or surrounded by the 100-yr or 500-yr floodplain.

Table 11 shows the current use of all floodplain properties in the Stillaguamish Basin. The data provided in this table was calculated by grouping the number of parcels and total acreage for each use code by watershed. Currently almost 58% of the floodplain in the basin is in agricultural use. The total of agriculture, timber, and vacant rural residential lots is over 78% of the floodplain area.

Table 11: Existing Floodplain Property Use.

Existing Use Designation	Data	Mainstem	North Fork	South Fork	Canyon Creek	Pilchuck Creek	Skagit Floodplain*	Grand Total
Agricultural	Number of Parcels	413	98	19	0	8	87	625
	Floodplain acres	9537	1530	438	0	93	1998	13597
Commercial	Number of Parcels	58	13	9	3	0	149	232
	Floodplain acres	180	11	58	10	0	115	374
Timber/Forest	Number of Parcels	6	52	30	17	6	0	111
	Floodplain acres	21	671	187	202	93	0	1174
Rural Residential	Number of Parcels	318	333	554	181	24	250	1660
	Floodplain acres	1539	1102	464	107	54	290	3556
Vacant	Number of Parcels	195	371	391	186	21	92	1256
	Floodplain acres	939	1086	989	98	162	415	3689
Other	Number of Parcels	41	54	46	15	8	14	178
	Floodplain acres	454	444	135	6	75	154	1268
Total Number of Parcels		1031	921	1049	402	67	592	4062
Total Floodplain acres		12669	4844	2272	423	478	2972	23658
*Skagit Floodplain refers to the coastal plain north of Stanwood within Snohomish County								

Table 12 shows estimates of potential future development, assuming that all lots are subdivided to the minimum size allowed. This information is for analysis only and is not intended to reflect actual development potential of individual parcels. It may overestimate the number of new homes possible due to other regulatory limitations on density and development such as streamside buffers and density fringe, but serves as a bookend for the conservative estimate.

A house was assumed to be on site if the market improvement value in the Assessor's database exceeded $10,000. The number of potential new homes possible was estimated by dividing the parcel acreage by the allowable dwellings per acre based on how the land was zoned. A parcel had to have 0.2 acres outside of the regulatory floodway to have new homes calculated. This arbitrary value was selected because it was assumed to be minimum area needed to construct a house.

As Table 12 shows, no new structures are predicted in the city limits of Stanwood or Arlington. However, the estimates show the importance of the agricultural zoned lands in future development scenarios in Unincorporated Snohomish County as over 67% of future new home construction can occur in this area. This is due to the large percentage of the floodplain zoned agriculture and the lack of a regulatory floodway in much of the mainstem that would prevent new development. This calculation does not take into consideration the restrictions placed on development in the density fringe area, which provides significant limitations on growth west of I-5.

Table 12: Land Use and Potential Future Floodplain Development.

Land Use	Data	[1]Mainstem	[1]North Fork	[1]South Fork	[1]Canyon Creek	[1]Pilchuck Creek	[1,2]Skagit Floodplain	Grand Total
Agriculture	Exist Homes	365	159	5	0	1	31	561
	New Homes Possible	793	147	29	0	1	193	1163
	Total Future Homes	1158	306	34	0	2	224	1724
Land use within City Limits	Exist Homes	48	0	8	0	0	357	413
	New Homes Possible	0	0	0	0	0	0	0
	Total Future Homes	48	0	8	0	0	357	413
Forest	Exist Homes	0	10	19	12	0	0	41
	New Homes Possible	0	16	7	3	0	0	26
	Total Future Homes	0	26	26	15	0	0	67
Rural Residential	Exist Homes	117	225	430	175	25	10	982
	New Homes Possible	134	175	104	4	70	23	510
	Total Future Homes	251	400	534	179	95	33	1492
Other	Exist Homes	16	2	119	0	0	0	137
	New Homes Possible	11	11	0	0	0	0	22
	Total Future Homes	27	13	119	0	0	0	159
Total Exist Homes		546	396	581	187	26	398	2134
Total New Homes Possible		938	349	140	7	71	216	1721
Total Future Homes		1484	745	721	194	97	614	3855

[1]This information is for analysis only and is not intended to reflect actual development potential of individual parcels.
[2]Skagit Floodplain refers to the coastal plain north of Stanwood within Snohomish County.

Given the results of these tables, to reduce future flood damages in the Stillaguamish River basin, new homes in the agricultural zone lands should be minimized. In addition to reducing future flood damages, preserving agriculture is, in and of itself, an important County goal set out in the GPP.

To date, floodplain development has been fairly low. There is and will always be pressure to allow increased development on the floodplain. In recent years this has been focused in the Island Crossing area between I-5 and Arlington. The long-term success of the County in minimizing future flood damages will rest in part on its success in the preservation of agriculture in the floodplain.

Evaluation of Alternative Actions

1. No Action. Existing zoning and land use codes would continue to guide future development.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: NA.
   d. Benefit and/or Cost. NA
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

2. Downzone Floodplain. Increasing the minimum lot size can reduce development pressures. For example, Skagit County zones agricultural land with a 40-acre minimum lot size rather than the 10-acre minimum Snohomish County uses. The County's GPP calls for investigating this option (Policy Land Use 7.D.1) on agricultural lands.
   a. Safety Risks: Low
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible. The majority of existing floodplain parcels are already less than 20 acres (basin-wide) and so densities may not be affected by downzoning. However, on the mainstem there are still many 30- to 40-acre parcels in existence so this alternative would be partially effective at limiting floodplain density.
   d. Benefit and/or Cost. This is a regulatory action that would require changing the County's zoning through its standard GMA procedure. Staff time and public involvement costs would be incurred. The benefits would be in preventing the subdivision of large agricultural parcels into 10-acre lots and the consequent flood risks all the new houses would be exposed to.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

3. Continue to promote Purchase of Development Rights/Transfer of Development Rights (PDR/TDR) and other voluntary programs, such as the Wetland Reserve Program, that give incentives for landowners to keep floodplain parcels in agriculture or other low density uses.
   a. Safety Risks: Low
   b. Environmental Impacts: Low. If future site-specific actions are identified as a result of implementation of voluntary programs, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. Both King and Skagit counties have implemented PDR programs. Typically, the landowner sells their rights to develop the land to an agency or other party, but retain ownership of the land.

They can then continue to farm the land as before, but cannot subdivide or otherwise develop the land into higher density or non-agricultural uses.

d. Benefit and/or Cost. The costs of setting up a PDR/TDR program is unknown, but County staff time would most likely be the major cost. Total PDR costs for the entire floodplain would run into the tens of millions of dollars. The cost of other voluntary programs is unknown.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 9: THE COUNTY SHOULD PROMOTE VOLUNTARY INCENTIVES TO CONTINUE LOW DENSITY FLOODPLAIN USE.

Continue to promote PDR/TDR and other voluntary programs that give incentives for landowners to keep floodplain parcels in agriculture or other low density uses.

ZERO RISE/COMPENSATORY STORAGE

Issue

The County's and City of Stanwood's Flood Hazard Ordinances (SCC30.65, and COS17.120) allow development in the density fringe and floodway fringe floodplain (described above). Development is allowed in the floodway fringe provided the cumulative increases in the water surface elevation are not more than one foot in the floodway (SCC30.91F.430 and SCC30.91F.440).

Floodwater Conveyance is a volume of water passing through a given area. When that "area" is blocked (e.g., a house is built), it results in a loss of conveyance. This loss forces floodwaters to flow through another area equal to the area that is lost, which can impact surrounding properties.

A Zero Rise Floodplain ordinance ensures that new construction will not cause a rise in flood levels on properties upstream or downstream of the site. There are two components to Zero Rise. One is no net loss of *floodwater conveyance* and the other is no net loss of flood storage.

Discussion

To meet the requirement that the elevation of the lowest floor of any new home be constructed at one foot above the 100-year flood levels, fill (e.g., earthen, concrete) is sometimes used to elevate a new home. This action reduces the ability of the floodplain to convey and store floodwaters because the area that was once used to "store" or "convey" floodwater is now "filled" by a structure. Placing fill in the floodway fringe portion of the floodplain is currently permitted provided the resulting increase in the flood elevations in the floodway is no more than one foot. This increase, however, could increase flows, water levels, and damages to current floodplain residents upstream and downstream of a new development.

To address this concern, some jurisdictions (e.g. City of Arlington and King County, Washington) have adopted more restrictive Zero Rise Floodplain ordinances to ensure that water surface elevations are not increased throughout the entire floodplain. The City of Arlington adopted the zero-rise and compensatory storage requirements in the 1990s. The City of Stanwood also has land on the floodplain, but their existing regulations do not contain these requirements. More information about their existing flood hazard reduction regulations and how they compare with Snohomish County's can be found in Appendix D.

No net loss of conveyance ensures that the ability of the floodplain to move floodwaters is not restricted by new construction (e.g., roads, houses). Reduced conveyance causes flood levels to increase upstream, and also can result in floodwaters being redirected onto other properties nearby. If an area that used to convey floodwater is "plugged" by a structure, an area of equal size would be required under this proposal to adequately convey that same volume of floodwater.

The storage component is needed to ensure that downstream properties are not impacted by upstream new construction. Fill or construction of structures on the floodplain reduces the available area that floodwaters can occupy. When floods spread out over the floodplain, the floodwaters are temporarily stored and then released after the peak of the flood passes. The result is that on large rivers such as the Stillaguamish River, flood peaks are reduced as the flood travels downstream. When floodwater storage volume is removed by new construction, flooding will increase downstream because more water is forced to remain in the channel and less can be stored. Downstream property owners will be subject to floods that arrive quicker, rise faster, and reach greater levels.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Unknown.
   b. Environmental Impacts: Unknown.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Unknown.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. Currently no plans or regulations direct this action.

2. Using the hydrology and hydraulic models developed for the Flood Insurance Re-Study (*RECOMMENDED ACTION 1*), conduct a zero-rise floodplain assessment, including compensatory storage and equal conveyance requirements, as the basis for future consideration of zero-rise provisions in the County's Flood Hazard Code.
   a. Safety Risks: None.
   b. Environmental Impacts: None. If future site-specific actions are identified as a result of this assessment, potential environmental impacts and necessary

mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

c. Technical Feasibility: Feasible.

d. Benefit and/or Cost: Unknown. Updates to Title 30.65 could be incorporated into on-going updates to the Critical Areas Ordinance, which may reduce costs.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 10: USING THE MODELING RESULTS FROM THE RFIS, CONDUCT A ZERO RISE FLOODPLAIN ASSESSMENT TO USE AS THE BASIS FOR CONSIDERATION OF ZERO-RISE PROVISIONS IN COUNTY CODE.

Using the models developed for the RFIS, conduct a zero-rise floodplain study, including compensatory storage and equal conveyance requirements, as the basis for future consideration of zero-rise provisions in the County's Flood Hazard Code in the CAR update process.

HIGH HAZARD ZONES

Issue

High Hazard Zones (HHZ) are areas where structures would be at risk of substantial damage or complete destruction due to rapid erosion rates, high velocities, or debris swept onto the banks. No current County or city code has the explicit purpose of preventing building in these high hazard areas, resulting in areas where building is allowed that may be at risk. Having these prohibitions in place would reduce damage to structures and can save lives.

Discussion

The County and city flood hazard codes (SCC Title 30.65, COS Title 17.120, COA Title 20.88) does not apply to areas out of the mapped 100-year floodplain. Therefore a structure could be sited on a piece of ground that is above flood level, but yet can be rapidly undercut by the river and destroyed. In areas where avulsion is a risk, such as at Chatham Acres (Page 7-42) on the North Fork Stillaguamish River, land can be hundreds or even thousands of feet from the current main channel and still be at risk.

Snohomish County is conducting a GMA-required evaluation of its Critical Area Regulation (SCC 30.62). As part of that update, Channel Migration Zones (CMZs) are being considered for incorporation into the regulation language. CMZs are a similar concept to HHZs except that the main purpose of CMZ is to ensure the habitat benefits of natural river migration are protected. The main purpose of identifying the HHZ of a river is to prevent the loss of life. It may be possible to map both the CMZ and the HHZ as part of the RFIS (*RECOMMENDED ACTION 1*) to reduce the costs associated with mapping them.

The process of delineating the CMZs and HHZs is similar in that former meander channels, avulsion risk areas, and areas of unstable soil are identified. In almost all cases, the methods proposed for CMZ delineation in current proposed methods (e.g., State Forest Practice code WAC 222.30.12) would fully enclose the HHZ. The primary difference from the regulatory perspective is that it would be recommended that development in HHZs be prohibited.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Unknown. Currently homes can be constructed in areas where the true flood risk in not accurately assessed.
   b. Environmental Impacts: Unknown.
   c. Technical Feasibility: NA
   d. Benefit and/or Cost: NA
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Map High Hazard Areas. Currently High Hazard Zones are not mapped in the County.
   a. Safety Risks: None.
   b. Environmental Impacts: None. If future site-specific actions are identified as a result the mapping process, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. Currently new construction is restricted in the floodway, but high hazard areas (such as avulsion risks) may be outside the mapped floodway. Because several methods to map the HHZ exist, one would need to be selected for use.
   d. Benefit and/or Cost: The cost of this effort is estimated at $250,000. Quantifying the benefits in terms of reduced flood damages would not be known until the study was complete. This effort could be combined with the Flood Insurance Re-Study (*RECOMMENDED ACTION 1*), which would reduce overall study costs.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. The County is currently evaluating potential updates the Critical Area Regulations (planned completion by 2004) and mapping the CMZ to protect habitat is part of that effort. The regulatory aspect of considering development provisions in the mapped HHZ could be coupled with the CMZ update, which would streamline the process and save money.

RECOMMENDED ACTION 11: MAP HIGH HAZARD ZONES.

Map high hazard areas in the Stillaguamish River basin that identify areas of high velocity, accelerated erosion rates, and potential for river to carry debris (e.g., trees) on land.

RECOMMENDED ACTION 12: USE THE MAPPED HIGH HAZARD ZONE AS THE BASIS FOR CONSIDERATION OF HIGH HAZARD ZONE PROVISIONS.

Use the High Hazard Zone and Channel Migration Zone maps as the basis for consideration of High Hazard Zone provisions in the upcoming CAR update process. Notify the County Assessor's office of all parcels in the mapped High Hazard Zone.

DEVELOPMENT NEAR STEEP SLOPES

Issue

Development near steep slopes is regulated under the County's Critical Areas Ordinance (SCC 30.62), but improper construction in these areas may increase the risk of a landslide, primarily on the mainstem. Stanwood regulates its steep slopes under Title 17.115 and Arlington under Title 20.88. They are similar to the County's code.

Discussion

In the Stillaguamish, the construction on or near steep slopes is mostly confined to the mainstem, where new houses have been built on the hilltops overlooking the floodplain. Trees are typically removed to enhance the view, which can make the slope more prone to sliding. The size of the river makes it unlikely that a slide could completely block the river, but could accelerate erosion or increase the sediment load.

For typical bluff heights of around 150 feet in the lower mainstem, building setback requirements will average around 50 feet (bluff heights may vary). In addition, steep slopes undisturbed by construction are required to be put into native growth protection areas, which prohibit vegetation removal.

Evaluation of Alternative Actions

1. No Action. New construction will continue to be regulated under CAR, SCC 30.62.

a. Safety Risks: Low. Because construction is near a hazardous location there will always be some level risk and uncertainty.

b. Environmental Impacts: Low. Resultant landslides may add sediment to the river system.

c. Technical Feasibility: NA.

d. Benefit and/or Cost: NA

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

2. Develop a homeowner education program providing information on risks of landslides and the benefits of retaining healthy vegetation on steep slopes.

   a. Safety Risks: Low. The result of this program could increase resident's understanding of landslide-associated risks.

   b. Environmental Impacts: Low. This type of program could improve retention of vegetation, resulting in fewer landslides. If future site-specific actions are identified as a result this homeowner education program, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

   c. Technical Feasibility: Feasible. Ecology has existing web and print information available that is targeted for coastal bluff property owners. Much of the information presented is also relevant for bluffs along rivers.

   d. Benefit and/or Cost: This alternative would be a relatively low cost outreach program. It would probably be best used on a County-wide basis along all coastal and riverine bluff areas.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

3. Conduct a detailed landslide hazard study and incorporate results into County regulations.

   a. Safety Risks: None.

   b. Environmental Impacts: None. The existing code provides for development setbacks at the toe of steep slopes and top of a bluff.

   c. Technical Feasibility: Feasible. In a report documenting the impacts of the Winter Storm of 1996-97, landslides were found to be most prevalent in areas where Esperance Sand formations overlaid Lawton Clay formations (Corps 1997). This type of information could be obtained and used to determine the associated landslide risks.

   d. Benefit and/or Cost: The study would cost at least $100,000 with significant additional cost and effort incurred to incorporate the results into County code.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 13: DEVELOP A LANDSLIDE HAZARD HOMEOWNER EDUCATION PROGRAM.

Develop an education program that provides homeowners who live above or below geologically hazardous areas information on the risks of landslides and the benefits of retaining healthy vegetation on slopes.

COMMUNITY RATING SYSTEM

Issue

The County currently does not participate in the voluntary Community Rating System (CRS), which when completed, provides flood insurance rate reductions to policyholders in the County.

Discussion

The CRS is part of the NFIP program that enables a community to go above and beyond the minimum standards for floodplain regulations. Eighteen floodplain management activities are credited by the CRS organized as follows:

1. Public Information: Includes elevation certificates, map information, outreach projects, hazard disclosure, flood protection library and flood protection assistance.
2. Mapping and Regulations: Includes delineation of floodways, coastal velocity zones, and base flood elevations, identifying and preserving open space (consistent with Parks Master Plan), altering regulations to prohibit fill or require compensatory storage, and implement low density zoning on floodplain.
3. Flood Damage Reduction: Includes identifying repetitive loss areas, preparing, adopting, implementing, and evaluation of floodplain management planning in areas not complete, acquisition and relocation, and retrofitting structures. Stormwater drainage improvements also receive credit.
4. Flood Warning: Includes flood threat recognition system, emergency warning dissemination, steps taken during a flood response, and critical facilities planning.

The County can "earn points" for floodplain management planning that results in a reduction of flood insurance rates for those living in unincorporated Snohomish County. The plan includes many of the same components involved in this flood hazard plan, but must be completed countywide. Many current County activities and regulations count for CRS points. It is possible that simply documenting these existing items in a CRS application would result in at least a one step reduction in flood insurance premiums. King County has obtained a rating that gives flood insurance policy holders a 30% reduction in their premiums by completing required components of the CRS.

A Countywide Repetitive Loss Plan is required by CRS. A repetitive loss is defined by FEMA as a property that has had two or more claims of at least $1,000 paid by the NFIP since 1978. The Repetitive Loss Plan must develop methods to address these recurring flood damages. According to the NFIP Repetitive Loss Survey, the Stillaguamish River basin has six repetitive loss properties, at least one of which has been flood-proofed, which has removed the repetitive loss potential.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: None.
   b. Environmental Impacts: None.
   c. Technical Feasibility: NA
   d. Benefit and/or Cost: NA.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Apply for CRS and complete a Repetitive Loss Plan.
   a. Safety Risks: None.
   b. Environmental Impacts: None. If future site-specific actions are identified as a result in the process of completing the CRS or Repetitive Loss Plan, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. Snohomish County is a Category C designated community as it has 10 or more repetitive losses (Countywide). Because of this designation, the County must undertake certain activities when participating in the CRS, such as mapping the properties, describing the causes, and developing an outreach program for each property. In addition, the County must complete a floodplain management plan for the repetitive loss areas.
   d. Benefit and/or Cost: In the first year, estimated costs are $50,000 to prepare a CRS application and repetitive loss plan. Thereafter, $2,000/yr would be required to prepare and update the annual reports required. The benefits would be countywide, and would result in a net flood insurance premium reduction of around $20,000 or more per year. Quantifying the benefits to the County is difficult, as it would benefit from improved flood warning capability, outreach and education opportunities, more accurate mapping, and reduced flood damages as a result of implementing the components of this action.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. The CRS is a voluntary program that provides incentives for incorporating flood protection activities above and beyond those that meet National Flood Insurance Program minimum standards. Participation exceeds existing flood hazard reduction standards.

RECOMMENDED ACTION 14: APPLY FOR THE NFIP COMMUNITY RATING SYSTEM.

Participate in the NFIP Community Rating System and complete a repetitive loss plan countywide.

RESTORATION/ENHANCEMENT OPPORTUNITIES

Issue and Discussion

Restoration areas or areas where enhancements could be made to improve flood storage or conveyance in the Stillaguamish River basin will continue to become available. Opportunities may present themselves after flood events, property sales, or property acquisition and these opportunities to coordinate efforts among various jurisdictions should continue to be pursued.

RECOMMENDED ACTION 15 and *RECOMMENDED ACTION 16* provide a mechanism to evaluate and participate in future flood hazards or flood hazard mitigation opportunities that develop after the plan is adopted.

RECOMMENDED ACTION 15: EVALUATE NEW FLOOD HAZARDS USING THE COMMITTEE-ADOPTED PROCESS.

Evaluate new flood hazards and flood hazard mitigation opportunities that may develop after plan adoption using the goals, objectives, and evaluation criteria established in this plan.

RECOMMENDED ACTION 16: PARTICIPATE IN HABITAT RESTORATION PROJECTS THAT PROVIDE CUMULATIVE FLOOD REDUCTION OPPORTUNITIES.

Participate in future habitat restoration projects (developed post-plan adoption) that may provide the added benefit cumulative flood reduction opportunities in the basin

7.2 Alternatives and Recommended Actions by Subbasin

This section of the plan identifies actions that are specific to each subbasin.

7.2.0 THE NORTH FORK OF THE STILLAGUAMISH RIVER

The North Fork Stillaguamish River begins in the Cascade Mountains. From River Mile (RM) 45 to RM15, the river is relatively steep with a narrow undeveloped floodplain. From RM15 to RM13, the river flows through the community of Oso. At approximately RM14, Deer Creek enters the North Fork system. Downstream of Oso, the river enters a relatively flat portion of the river system with wider floodplains.

WHITEHORSE TRAIL

Issue

Construction of the Burlington Northern Railroad (BNRR) in the early 1900s resulted in many areas where the river was straightened or side channels and wetlands were isolated from the main channel. This has reduced the natural flood storage capacity the floodplain once had, potentially increasing downstream flows and damages.

Discussion

The White Horse Trail (WHT) is a 27-mile long corridor that was acquired by the County from Burlington North Railroad through a rail banking process in 1993. It runs up the North Fork Stillaguamish River valley from Arlington to Darrington.

The North Fork Stillaguamish River abuts the White Horse Trail and SR530 in at least seven locations. At these locations, the bank has been armored with riprap, log deflectors, groins or a combination of these stabilization methods to prevent continued damage. These sites are regularly monitored during and following flood events because they continue to be susceptible to damage.

When BNRR owned and operated the railroad, it would flood fight by placing rock on the riverbanks where erosion was occurring. Snohomish County Parks and Recreation Department (Parks) will not conduct that same practice because of costs and permitting challenges. Parks generally will not conduct flood-fighting efforts to save a threatened portion of the trail unless other public infrastructure is also threatened.

As part of the rail banking agreement, the County must maintain the easement. The rail banking agreement does not preclude reconnecting isolated side channels and floodplain areas to the river. Reconnection options could include culverts, bridges, and overtopping sections. Parks is currently conducting a culvert inventory, which is planned for completion in 2002.

Several public areas were identified for possible reconnection that may increase flood storage capacity (e.g. Cloverdale Park, Cicero Park), but a more intensive study would be required to verify the benefit and to identify additional opportunities along the river system.

Evaluation of Alternative Actions

1. No Action
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: None.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Reestablish connectivity between the river and side channels through the White Horse Trail where possible.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. If future site-specific actions are identified as a result reestablishing connectivity, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. Hydraulic modeling and additional analyses would be required to evaluate potential storage capacity, expected water levels, and impacts. In addition, habitat enhancements such as installation of large woody debris or increased complexity in the area can be made to achieve multiple purposes such as slowing flows and improving habitat. The added floodwater storage capacity may reduce the downstream impacts of flooding, meeting several goals and objectives of this plan. The update to the Flood Insurance Study would assist in the completion of this alternative. Reductions in downstream water surface elevations could be achieved if sufficient upstream floodplain area is reconnected to the river.
   d. Benefit and/or Cost: Unknown. The cumulative benefits of improving flood storage capacity by reconnecting the river to channels that were isolated from the North Fork Stillaguamish River are unknown.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 17: REESTABLISH CONNECTIVITY BETWEEN THE RIVER AND SIDE CHANNELS THROUGH THE WHITEHORSE TRAIL WHERE POSSIBLE.

Determine the benefits and feasibility of reconnecting the river to former meander channels or storage areas where the existence of the Whitehorse Trail reduces flood storage capacity and implement findings.

TRIBUTARY BRIDGES

Issue

Several county bridges cross tributaries to the North Fork. These bridges have chronic maintenance requirements due to sediment deposition under and near each of the bridges. Bridges on Segelson, Black, Frye, and Swede creeks on the North Fork are currently maintained by annual dredging. Traditionally the gravel has been dredged out as necessary in an attempt to prevent roadway flooding. This method of maintenance is a continuing cost and is increasingly difficult to complete due to permitting issues and impacts to water quality and fish habitat. A long-term solution to on-going maintenance is desired.

Discussion

Each of these bridges is located in areas where the creek enters an alluvial fan with a significantly flatter gradient. Subsequently, sediment is deposited around the bridge structures and downstream reaches, potentially increasing flooding and damages to the bridges and nearby houses (Conversation with Dick Sass, Snohomish County 2001).

Since the bridges were constructed, they have been regularly maintained by dredging gravel deposits. Dredging around the structures prevents sediment build-up and the potential for subsequent damage to the structures.

Backwatering occurs when water flows through a constriction (e.g., under a bridge) forcing the water to "stack up" on the upstream side of the constriction. This causes higher water levels than would occur if the constriction did not exist.

Currently a bedload study is being conducted on each of these creeks for Snohomish County Public Works Engineering Services Division to determine alternatives to annual dredging. Assessments of Fry Creek Bridge (#316) and Black Creek Bridge (#602) have been completed. The results of the Fry Creek Bridge assessment indicate that because of the bridge's proximity to the North Fork Stillaguamish River, *backwatering* effects of the main river may control aggradation near this structure. This means that a larger spanning bridge may not resolve the on-going aggradation issues (R2 Resource Consultants 2001a).

Black Creek Bridge results indicate that the bridge is too far upstream to be impacted by backwatering of the North Fork Stillaguamish River. This assessment documents that the elevation of the low chord (lowest elevation of a bridge girder) of the bridge may be the cause of aggradation issues. This means that elevating the bridge may address aggradation issues (R2 Resource Consultants 2001b). The preliminary results of this work reflect the need to study each structure individually before a solution can be determined.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Low.
   b. Environmental Impacts: High. Taking no action will not eliminate the need for on-going maintenance of the structures. Continued dredging will be required, which will impact the aquatic habitat.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Costs/dredging event is approximately $2,000. Dredging has been conducted up to five or six times per year depending on the flow during any season so costs can be up to $10,000 or $12,000 per year.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. While consistent with County policy, environmentally sensitive alternatives to minimize the effects on aquatic ecosystems should be pursued. In addition, alternatives to dredging should be sought.

2. Add an additional span to each bridge, which would widen the area the river could flow through.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Unknown. It is not clear if widening or elevating the bridges would eliminate aggradation in the channel. This action would leave existing piers/piles in the tributary channel, which would not completely eliminate the constriction to flow.
   d. Benefit and/or Cost: $300,000, which includes the potential for right-of-way acquisition. If major improvements such as bridge widening, approach changes, and steel or concrete girders are required, a new span can cost up to $1 million dollars.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

3. Construct new, single-span bridge at each location that does not constrict sediment transport. A single span bridge would not contain piers/piles in the tributary channel.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Unknown. It is not clear if widening or elevating the bridges would eliminate aggradation in the channel
   d. Benefit and/or Cost: $250,000 (timber bridge within existing footprint) for a new bridge compared to $10,000 or $12,000 per year for current dredging practices. New bridges can cost up to $1 million dollars if major improvements such as bridge widening, approach changes, and steel or concrete girders are required.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

4. Study the potential of constructing a sediment trap upstream of selected bridges and dredge regularly. If feasible, implement alternative.
   a. Safety Risks: Low.
   b. Environmental Impacts: Unknown.
   c. Technical Feasibility: Unknown. A study of the area would be required to determine flows, sediment loads, and potential area need to capture sediment inputs.
   d. Benefit and/or Cost: A study may cost up to $75,000 compared to $10,000 or $12,000 per year for current dredging practices. Implementation costs are unknown.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
5. Implement results of current bedload study of bridges on tributaries to the North Fork to determine the best possible alternative (adding a span, constructing a new bridge) for eliminating the need for continued annual dredging.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. If future site-specific actions are identified as a result bedload studies, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: High.
   d. Benefit and/or Cost: $10,000 to $12,000 per assessment (two are complete). Implementation costs vary.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 18: IMPLEMENT RESULTS OF CURRENT BEDLOAD STUDY TO ELIMINATE NEED FOR CONTINUED ANNUAL DREDGING.

Implement results of current bedload study of bridges on tributaries to the North Fork to determine the best possible alternative (adding a span, constructing a new bridge) for eliminating the need for dredging.

SWEDE HEAVEN ROAD

Issue

Significant bank erosion is occurring on the left bank of the river and is threatening public infrastructure (County bridge and road) and residential structures. County road engineers are currently investigating solutions to this problem (Appendix G, Figure G2).

Discussion

The river is eroding its left bank adjacent to Swede Heaven Road near RM30. An avulsion is possible, but unlikely because the left bank is on an abandoned terrace above the 100-year floodplain. Upstream of this site, two sections of riprap totaling about 600 feet have been placed along the right bank of the river. That bank hardening, according to a study conducted by RW Beck (2000), may have affected the flow path near the project site. Rock has also been placed on the right bank downstream of this area as well.

The channel has experienced significant lateral migration and downcutting in recent years. Lahar deposits from Glacier Peak, which are primarily composed of boulders and cobble, dominate the geology. Alluvial fan deposits, consisting primarily of sands and gravels from the Holocene period are also present. The rate of channel migration was estimated by reviewing aerial photography between 1949 and 1991. In addition, survey work that was completed in 1993, 1998, and 2000 was compared. Results indicated that modest lateral migration occurred from 1948 to 1984 (approximate 0.4 ft/year). Between 1984 and 1998, migration rates increased to a rate of 4 ft/year, a rate 10 times that of the previous 36 years. The most significant lateral movement occurred in the years 1984, 1990, 1997, and 1998 (RW Beck 2000).

In addition to lateral migration of the channel, RW Beck (2000) also evaluated aggradation and degradation by comparing elevations where the main current of the river flows. Between 1990 and 2000, the cross sections near the bridge indicated a 1 to 2 foot increase in channel depth. This may be attributable to a wider new bridge, which was constructed in the 1990s. Over a longer time period between 1970 and 2000, the channel degraded between 2 to 6 feet, which may indicate localized scour.

Flood flows on the North Fork Stillaguamish increased in magnitude and frequency beginning in the 1980s. These higher flows and subsequent increased velocities and sediment transport are some of the causes for the failure of the riprap and increased potential of river avulsion. Currently, Snohomish County Public Works Department is attempting to protect county-owned Swede Heaven Road from further erosion (RW Beck 2000).

RW Beck (2000) identified several alternatives to prevent further channel migration threats to protect public infrastructure. Because the site is prone to high erosion

rates and high shear stresses, alternatives included a variety of bank stabilization measures incorporating habitat components, such as log deflectors, in addition to providing the required armoring to protect the public infrastructure. Non-structural measures, such as acquisition of land from willing sellers, were not included in their analysis.

The recommended action was to install groins[1] and barbs[2] along the left bank of the river. Large woody debris was included in the design to improve fish habitat. The recommended action was presented to various agencies including the federal services, NMFS and USFW. As part of the informal consultation required by Section 7 of the ESA, meetings were held with the federal services, which recommended that Swede Heaven Road be moved and properties relocated because they expected continued lateral migration.

Because a County road was at-risk, Snohomish County Road Maintenance secured funding and began implementation of this action in 2003.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: High. One existing home, which is located between the river and Swede Heaven Road, is at significant risk as the channel continues to migrate laterally.
   b. Environmental Impacts: High. If no action is taken, the river will undercut the road. At that point, the County will be forced to perform emergency repairs to keep the road open. Emergency repairs are generally limited to dumping rock to prevent further erosion. By waiting until roadway failure to act, the end result will most likely be a bank armored with rock.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Emergency repairs, and the required post-flood permitting and mitigation are estimated to cost as least as much as Alternative Action 2.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. The home is located on an abandoned terrace above the 100-year floodplain outside of the floodway.
2. Stabilize bank and pursue voluntary acquisition of single property.
   a. Safety Risks: Low. Design would reduce risk of further channel migration and encourage river to remain in existing alignment. Acquisition of property would eliminate the threat to life and property in the area between the road and river.

[1] For the purposes of this plan, groins are rock deflectors that move the flow path of the river away from the riverbank. The top of the groin is placed at an elevation that achieves that goal, which in the case of this action was a 25-year event.

[2] For the purposes of this plan, barbs are similar to groins except that they are placed lower in elevation and are overtopped during bankfull flood events (1-2 year event).

b. Environmental Impacts: Moderate. During construction, sediment disturbance is likely and the potential for additional sediment input to the system will be increased. Erosion protection and timing of construction effort can minimize these inputs. After construction, the bank will be secured and continued sediment load from on-going erosion would be controlled. Although this would be a stabilized, hardened bank, habitat impacts would be reduced through installation of log deflectors. Potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

c. Technical Feasibility: Feasible. The natural berm/bank provides flood reduction benefits to residents in area and care should be taken that those benefits are not reduced by the stabilization effort.

d. Benefit and/or Cost: $305,000. Costs include clean up of site. The acquired area would be used as a native growth protection area. On-going maintenance costs (costs unknown) would be associated with this action.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent. Current County policy allows for bank stabilization efforts to be used as a measure to protect infrastructure from the threat of bank erosion.

3. Pursue voluntary acquisition of several properties and relocate road.

a. Safety Risks: Low. If the road and the residential structure that is between the road and the river are relocated, the risk to life is reduced.

b. Environmental Impacts: Low. All work would be conducted away from the river channel and would allow the establishment of a riparian buffer along the right bank.

c. Technical Feasibility: Feasible. To relocate the road substantial property would need to be acquired including several residences. The road could be moved back sufficient distance that the river would take many decades to migrate over to it. This option allows for the river to continue migrating and reduces the threat to the road, as well as removing homes at risk. The natural berm/bank provides flood reduction benefits to residents in area and care should be taken that those benefits are not reduced by this action.

d. Benefit and/or Cost: $655,000 for road relocation, and acquisition of three properties or relocation of three houses. Costs are substantially greater than the previous alternatives due to property acquisition and new road construction costs.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

4. Pursue voluntary acquisition of several properties (or relocate houses), relocate the road, and install a cut-off wall adjacent to it to allow the river to continue to migrate.

a. Safety Risks: Low. If the residential structure that is between the road and the river is relocated, the risk to life is reduced.

b. Environmental Impacts: Low. All work would be conducted away from the river channel and would allow the establishment of a riparian buffer along the right bank.

c. Technical Feasibility: Feasible. This option allows for the river to continue migrating up to the installed cut-off wall, reducing the threat to the road and removing the homes and lives that may be at risk. The natural berm/bank provides flood reduction benefits to residents in area and care should be taken that those benefits are not reduced by this action.

d. Benefit and/or Cost: $930,000 to $1.13 million depending on the type of wall constructed. The road will need to be setback away from the river before the cut-off wall can be constructed. This option also includes acquisition of three properties. Costs are substantially greater than the previous alternatives due to property acquisition.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 19: STABILIZE SWEDE HEAVEN BANK AND PURSUE VOLUNTARY ACQUISITION OF PROPERTY TO PROTECT TO COUNTY ROAD.

Stabilize bank and pursue voluntary acquisition of property to provide continued protection to public infrastructure (Swede Heaven Road and bridge).

CHATHAM ACRES

Issue

This reach of the North Fork is threatening to avulse through Placid Creek upstream. Accelerated bank erosion and the continued threat of channel migration are significant even during low flows (Appendix G, Figure G2).

Discussion

During a 2 or 3-year flood event in 1999, a channel avulsion occurred and one cabin was destroyed. In addition, seven other cabins were in danger of being seriously damaged. Another avulsion risk exists further upstream at the entrance of Placid Creek. To reduce that risk, the community installed a flow control structure (date unknown) at the upstream end of the creek.

Emergency bank stabilization was completed in 2000 and additional efforts to stabilize the bank upstream of the 1999 avulsion have been unsuccessful because of permitting requirements and associated costs. The County is limited in using public funds to provide assistance to this area because public infrastructure is not threatened.

All of the dwellings except one are located in the floodway of the river, which would no longer be permitted under existing regulations. Of the ten cabins in the area,

four are occupied year-round (Communications with John Newsom, Vice President of the Chatham Acres Association 2001).

After the federal disaster declaration following the February 2001 earthquake, federal funds were made available to the state so that local jurisdictions could address their specific hazards. Snohomish County Surface Water Management staff submitted a $1.9 million dollar Hazard Mitigation Grant. This grant was awarded in June 2003 in large part due to the extensive public process and detailed analysis conducted as part of the completion of the Stilly Flood Plan.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: High. Should an avulsion occur through Placid Creek, the only access road in and out of the area would be eliminated. This is the only access for emergency vehicles as well.
   b. Environmental Impacts: High. An avulsion could potentially wash away septic tanks, vehicles, houses, and other personal property.
   c. Technical Feasibility: Not applicable.
   d. Benefit and/or Cost: Unknown. Since the avulsion in 1999, the County has spent staff time working with the landowners to develop solutions to the continued accelerated erosion. Emergency repair efforts in 2000 cost approximately $21,000 and additional short-term bank stabilization efforts upstream were estimated at $30,000, which did not include on-going maintenance costs or additional studies required as part of the permit process.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Bank Stabilization.
   a. Safety Risks: Moderate. This alternative may lessen the risk to life, but not eliminate it. Because this river is very dynamic in this area, this option is not considered a permanent repair.
   b. Environmental Impacts: High. This alternative would introduce new bank armoring in the core chinook spawning area in the Stillaguamish.
   c. Technical Feasibility: Low. Effective bank stabilization is not feasible from an engineering standpoint because the area is very unstable and consists of predominately sands and gravels, which are easily eroded. Any economically feasible engineered project would not be expected to withstand the erosive forces of the river over the long-term without substantial maintenance and repair costs. In addition, bank stabilization would not eliminate the risk of overtopping during a large flood event, which is generally the mechanism through which an avulsion occurs.
   d. Benefit and/or Cost: Initial cost of engineering design and construction is expected to be high. Emergency repair efforts in 2000 cost approximately $21,000. Additional short-term bank stabilization efforts upstream were

estimated at $30,000, which did not include on-going maintenance costs or additional studies required as part of the permit process. Actual costs of an engineered structure that substantially reduces the avulsion risk is estimated at $930,000. Expensive structures would need to be constructed to stabilize the bank on a long-term basis.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent. All homes in floodway are considered nonconforming uses. They are grandfathered (most built in 1930s and 1940s), and would not be allowed in a floodway under current code.

3. Voluntary acquisition and demolition of homes using non-County funds.

   a. Safety Risks: Low. Eliminates the threat to life.

   b. Environmental Impacts: Low. Acquiring property eliminates environmental impacts of avulsion and subsequent loss of septic tanks, structures, and vehicles. The area will be designated as open space in perpetuity and recreational opportunities promoted. Potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

   c. Technical Feasibility: Feasible. All applicants are willing sellers.

   d. Benefit and/or Cost: The estimated cost is $1.9 million dollars. Hazard Mitigation Grant Program grant funding results in 75% federal funding, 12.5% state funding, and 12.5% local cost share, which will be voluntarily donated by the landowners. This alternative would eliminate costs of continued flood damages and threat to life. The minimum estimated quantifiable benefits would be $1.38 million. This does not include the risk of loss of life.

   e. Consistency with Applicable Land Use Plans and Regulations. Consistent. Acquisition would make the area consistent with current land use plans by removing structures from the floodway (construction pre-FIRM).

RECOMMENDED ACTION 20: PURSUE VOLUNTARY ACQUISITION OF CHATHAM ACRES.

Work cooperatively with Chatham Acres residents to pursue acquisition of ten structures and approximately 28-acres of property using non-County funds.

STEELHEAD HAVEN LANDSLIDE

Issue

Steelhead Haven Landslide (SHL) inputs significant sediment loads to the North Fork Stillaguamish River (Appendix G, Figure G2). A risk to life and property on the opposite river bank may exist should another major slide occur. Sediment input is a limiting factor to salmon production. A project to address this slide was

included in the Stillaguamish River Ecosystem Restoration Study (Corps 2000). Implementation of this project is being led by the Stillaguamish Tribe (Chapter 6).

Discussion

SHL is located at approximately RM20 on the north bank (right bank looking downstream) of the North Fork Stillaguamish River. This mud and clay slide occupies approximately 75 acres. In a report by GeoEngineers (April 2001a) it was estimated that the runout distance from a new major slide at this location is approximately 900 feet. Most of the area on the south bank (opposite the slide) is within this runout zone. That south bank is primarily vacant lots, but some homes are present as well. Smaller failures could also block the current flow of the river forcing the river into a new pathway, which would again threaten life and property on the south bank.

The slide has resulted in heavy silt deposits downstream of the site, which has destroyed spawning habitat for fish. GeoEngineers documented that this slide is the principal limiting factor for salmon production in the reaches downstream of the site. It continues to erode from the toe of the slide, emitting large volumes of fine sediment to the system.

Several options were developed as part of the GeoEngineers' study. In addition to no action, alternative actions included stabilizing the toe, creating a storage area for landslide materials, buyout of the floodplain, and protecting the area equivalent to the landslide runout potential. The preferred option was to allow the landslide to continue to occur, but providing a series of "storage areas" in the current flow path of the river to trap sediment from the slide. Over time, these storage areas would fill and the river would naturally move away from the slide creating a new channel.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Medium. The slide is not expected to stabilize naturally.
   b. Environmental Impacts: High. Continued sediment inputs will be significant and the downstream channel will not quickly fully recover until addressed.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: None. There are continuing economic costs from the long-term degradation of salmon habitat downstream.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Pursue voluntary acquisition of properties in runout area.
   a. Safety Risks: Low. Voluntarily purchasing all the property and relocating structures would eliminate the threat to life and property. In addition, the river would be able to recapture the abandoned terrace.

b. Environmental Impacts: High. This alternative would not reduce the sediment impacts of the slide on the river downstream.

c. Technical Feasibility: Feasible.

d. Benefit and/or Cost: The costs of property acquisition and relocation would be significant, but would remove the risk to human life and structures. This alternative would not reduce the environmental degradation caused by the slide.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

3. Construct a slide stabilization project that meets public safety as well as environmental restoration goals. As part of this project, the landslide and flood risk to residents can also be reduced or eliminated.

   a. Safety Risks: Low. The Stillaguamish Tribe and other partners are considering public outreach efforts and possible voluntary acquisition of select properties in potential slide run-out area that would reduce the risk to life.

   b. Environmental Impacts: Low. Potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

   c. Technical Feasibility: Feasible. Although this may be technically feasible, stabilizing any large slide such as this is a difficult task.

   d. Benefit and/or Cost: Significant funding is likely available for this site as one of the identified projects in the Corps Stillaguamish Ecosystem Restoration Study (2000). The Stillaguamish Tribe is pursuing a partnership with the Corps to design a project to reduce the environmental degradation the slide is causing. Large environmental benefits could result.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 21: IMPLEMENT A STEELHEAD HAVEN SLIDE STABILIZATION PROJECT.

Implement a stabilization project through the authority of the Corps that meets public safety and environmental restoration goals of this plan.

BRADLEY SITE

Issue

The "Bradley Site" is located just upstream of the former Burlington Northern Railroad (BNRR) steel truss bridge (now part of the White Horse Trail). Approximately 200 feet downstream of the BNRR bridge is the Washington-State North Fork/Oso concrete bridge at Mile Post 33.85 (RM15.83) on SR530 (Appendix G, Figure G1).

Approximately 800 lineal feet of riprap once armored the right bank of the river upstream of the former BNRR bridge. The downstream 300 lineal feet of this riprap has washed away and up to 80 lineal feet of bank erosion has occurred. There may be a threat of continued erosion upstream of the former BNRR bridge and the downstream SR530 bridge. There is also some concern of the river overtopping SR530 during a major flood event because of the backwatering effects of the two bridges. In addition, immediately downstream of the SR530 bridge on the left bank a series of small riverfront lots with residences are also threatened by bank erosion.

Discussion

When County staff investigated this site in 1995, records indicated that a river avulsion occurred upstream of RM17 through an old remnant channel in the 1951 flood. This changed the upstream channel alignment in a way that precipitated the channel meandering that now potentially threatens the trail system (former BNRR system) and highway.

During flood events, the railway bridge creates a backwater effect causing water to overtop the right bank. The river flows behind the remnant rock toe, impacting the armored railroad embankment. In addition, low swales on the property upstream provide a pathway for flows to reach Brooks Creek Road and SR530 to the southwest.

Because the former railroad approach embankment is upstream of the SR530 bridge, it dissipates some of the river's energy providing some protection to the downstream structure. According to Washington State Department of Transportation (WSDOT) personnel, the SR530 bridge experienced significant scour until riprap was installed in 1975. WSDOT staff regularly monitor this bridge for scouring problems.

Private property owners on the left bank of the river downstream of the SR530 bridge (237th AV NE) are also experiencing bank erosion. A high flow channel on the left bank is accelerating erosion that is threatening homes and property.

County staff completed preliminary designs of bank stabilization and log deflector installation upstream of the former BNRR bridge in 1995 to protect the rail bridge and SR530. The proposed design should reduce potential debris jams, reduce velocities, and limit accelerated erosion.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Low. Should SR530 overtop, residents to the east may be cut off from emergency access.
   b. Environmental Impacts: Moderate. Erosion will continue to provide sediment inputs to system. Continued erosion and eventual damage to the Whitehorse Trail bridge, SR530, the North Fork/Oso Bridge is expected.

c. Technical Feasibility: NA

d. Benefit and/or Cost: None

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

2. Augment preliminary engineering assessment and implement findings to stabilize the bank, improve habitat, and protect surrounding infrastructure.

   a. Safety Risks: Low.

   b. Environmental Impacts: Improved Conditions. Reduces sediment inputs to system and improves habitat. Use of large woody debris or other habitat-friendly stabilization measures should be pursued to stabilize the bank. If future site-specific actions are identified as a result of this assessment, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

   c. Technical Feasibility: Feasible. The design protects two bridges and State Route 530.

   d. Benefit and/or Cost: Unknown. Estimated costs for the initial design and construction are expected to be between $75,000 and $100,000. Protection provided to public infrastructure (both the former BNRR bridge and SR530) has not been quantified.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 22: COMPLETE ENGINEERING ASSESSMENT TO STABILIZE BRADLEY SITE BANK, IMPROVE HABITAT, AND REDUCE POTENTIAL DAMAGE TO PUBLIC INFRASTRUCTURE.

Augment preliminary engineering assessment that proposed bank stabilization, habitat improvements, and provided protection to surrounding public infrastructure at the Bradley Site to address accelerated erosion upstream and downstream of public infrastructure.

HAZEL HOLE

Issue

Hazel Hole is located at approximately RM22. The Whitehorse Trail is situated between the river at this location and SR530. The river flows directly into the bank and reverses direction upon impact. Bank erosion is still visible above the riprap and continued monitoring is required (Appendix G, Figure G2).

Discussion

Snohomish County has repaired this trail site because of severe bank erosion, the most recent of which was in 1997. Repair efforts involved installation of rock groins and riprap. Because of the potential impact to SR530, this area is also regularly monitored by the WSDOT. Most of the trail right-of-way has already been lost at this site, and the 1997 repairs are now protecting the highway.

Evaluation of Alternative Actions

1. No Action. Loss of trail and eventual damage to SR530 could be expected.
   a. Safety Risks: Low. May inconvenience residents to the east of the eroded point. Access to upstream sites would be through the Mountain Loop Highway until road was repaired.
   b. Environmental Impacts: Medium. If road and trail corridor erodes, sediment inputs could occur.
   c. Technical Feasibility: NA
   d. Benefit and/or Cost: Unknown. Repair of SR530 and trail corridor.
   e. Consistency with Applicable Land Use Plans and Regulations. Consistent.
2. Continue repair of the site.
   a. Safety Risks: Low. May inconvenience residents to the east of the eroded point. Access to upstream sites would be through the Mountain Loop Highway until road was repaired.
   b. Environmental Impacts: High. Each repair requires construction equipment near or in-stream, which may impact fish habitat and reduce water quality.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Unknown. Continued repairs to this site are expected. SR530 is an important transportation corridor that provides a high level of public benefit.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
3. Relocate SR530 away from the river's flow.
   a. Safety Risks: Low.
   b. Environmental Impacts: High. To relocate SR530, much of the landscape on the south side of the road would need to be altered for turning radius and line-of-sight requirements at the design speed (approximately 50 miles per hour).
   c. Technical Feasibility: Feasible. Shifting the road south would most likely impact utilities (power/telephone services) that are approximately 600 feet south of the road's centerline. Because of their proximity, they may need to be relocated as

well. In addition, a residence is located approximately 1,600 feet west of this site (south of SR530), which may need to be acquired if road geometry and utilities are altered.

d. Benefit and/or Cost: Unknown. Cost of relocating the road, utilities, and potential purchase of property is unknown, but most likely cost prohibitive.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

4. Determine potential of training main flow of river through abandoned channel away from SR530.

   a. Safety Risks: Low.

   b. Environmental Impacts: Low. This alternative may provide significant habitat improvements and remove the continued erosion threat to SR530. A former meander channel upstream may be available to redirect the main flow of the river through. If future site-specific actions are identified as a result of this assessment, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

   c. Technical Feasibility: Unknown. Issues include land ownership, river and abandoned channel geometry (has river incised - cut downward into the channel bed - too much to make this a viable option?), and existing river hydrology and hydraulics.

   d. Benefit and/or Cost: Unknown. A feasibility study would cost from $20,000-$40,000.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. Relocating the main flow of the river to a former meander channel would eliminate the need for continued repair work at this site. Action satisfies the self-sustaining objective, as it will require little to no maintenance in the future, which reduces the costs associated with flood hazard management.

RECOMMENDED ACTION 23: DETERMINE FEASIBILITY OF TRAINING MAIN FLOW OF RIVER AT HAZEL HOLE WASHOUT THROUGH UPSTREAM ABANDONED CHANNEL.

Conduct engineering and habitat analyses to determine feasibility of relocating river through an abandoned channel upstream of Hazel Hole to reduce damages to Whitehorse Trail and SR530.

OSO AREA

Issue

The community of Oso is located at the confluence of Deer Creek and the North Fork Stillaguamish River. Residents in the Oso area have experienced increased flooding and accelerated bank erosion from both rivers due, in part, to geomorphologic changes in both river systems and hydrologic changes in both basins. Flood control structures, bank erosion, aggradation, peak flooding changes, and future sediment transport potential need to be more closely evaluated to develop solutions for area residents (Appendix G, Figure G3).

Discussion

Private and public flood control structures in the area include Deer Creek Dike (private), Bridge 89 Dike (public), Oso Levee (right bank – public), Oso Levee (left bank – private), and the bank stabilization of Oso Loop Road. All of these structures are within approximately a 3-mile radius of each other. Because of that, the area, not just a specific structure or site, should be evaluated.

Oso Levee (right bank)

This structure is located downstream of the confluence of Deer Creek and the North Fork. It was originally built around 1940 by the Civilian Conservation Corps to protect a private farm, recreational property, and SR530 from bank erosion and flooding. According to Corps documentation, this structure provides protection for a 5-year flood event (plus one foot freeboard). Since its construction, Oso Levee has experienced repeated flood damage. Table 13 provides information on the year, estimated costs (if known), and flood frequency (numbers will be adjusted for inflation in subsequent drafts).

Table 13: Summary of Repair Costs for the Oso Levee (Right Bank).

Year	Estimated Cost ($)	Comments (not all costs indicated below were paid for entirely by the County)
1951	Unknown	Damaged by a 5- to 10-year event
1975	46,500	Damaged by a 5-year event
1979	Unknown	Damaged by a 2-year
1990	40,000	Damaged by a 25-year
1991	4,722	Follow-up repair.
1994	12,000	Additional repair work.
1997	38,939	Damaged by multiple floods in 1995 and 1996 and one event in 1997
1999	13,000	Damaged by a shift in channel alignment in 1995. Profile leveling and enhancements to top bank were required before construction equipment could access the site.
Annual Costs	3,700	Estimated costs completed in 1997. Annual costs may have increased since then.

Oso Loop Road

The left bank of Oso Loop Road is located on the left bank of the North Fork Stillaguamish River upstream of the mouth of Deer Creek. This road has experienced erosion due to high river velocities (6 to 10 feet per second). The river is incising (cutting downward in the channel bed) and undercutting the bank, which is layered with clay, sand/gravel, and a dense till with sand, silt, gravel, and clay. This site was damaged in each of the floods of the 1990s.

In October 1995, the County proposed a three-phased repair to protect the County road totaling approximately 1,100 lineal feet. Two of the three phases have been completed. Phase 1, which was completed in October 1995, was an emergency project in which 250 linear feet of the river were stabilized with three rock groins, riprap, and tree plantings. Phase 2, which was completed in 1997, consisted of adding an four additional rock groins spanning 650 linear feet. In addition, pipes were installed under the road to address landside drainage concerns. The third and final phase has not been completed, but provides additional bank protection.

Deer Creek Structures

Deer Creek Dike (private) and Bridge 89 Dike (public) are both located on Deer Creek. Deer Creek is a very flashy river that traverses through canyon-like terrain before exiting into a broad valley floor in the lower 1.5 miles. The steep gradients upstream of the valley area tend to capture debris, which in turn traps large volumes of water behind it. The debris dam eventually breaks, and the resulting high waters impact private and public property downstream.

In March 1997, a flood event on Deer Creek eroded the left bank 12 feet landward for a distance of almost 300 linear feet threatening, East Deer Creek Road. Funding to protect East Deer Creek Road was secured for the bank stabilization effort in 1997 through the County's Cooperative Bank Stabilization Program and from road funds. In early October 1997, three rock groins were installed on the left bank of Deer Creek just upstream of RM1 as part of an emergency response to accelerated bank erosion from the March 20, 1997, flood event. On or about October 30, 1997, shortly following the completion of the emergency work, a logjam broke near the headwaters of Deer Creek that again threatened property and East Deer Creek Road. The rock groins protected both private and public property.

In 1997 and early 1998, the County and local residents developed a flood damage reduction study to address concerns about area drainage, flooding, bank erosion, and access to homes. Some of the possible solutions under consideration at that time included bank stabilization, land acquisition, elevation of the county road, scour protection, floodproofing homes in critical areas, construction of overtopping flood control structures, culvert analysis, and flood warning. In addition, the community was encouraged to become a special purpose district that would enable them to obtain funding from local, state, and federal sources.

All of the work proposed in the flood damage reduction study required significant engineering analyses, habitat assessments, watershed investigations, and interagency cooperation. Funding for implementation of the proposed study was not available at the time.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Low. Overtopping would occur with subsequent inundation.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible
   d. Benefit and/or Cost: Unknown.
   e. Consistency with Applicable Land Use Plans and Regulations: Unknown.
2. Conduct a detailed study in the Oso/Deer Creek area to address on-going flooding and erosion issues and implement findings.
   a. Safety Risks: None.
   b. Environmental Impacts: Dependent upon recommended actions that result from the study. If future site-specific actions are identified as a result of this detailed study, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Estimated cost of study is $150,000.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 24: CONDUCT A DETAILED STUDY IN THE DEER CREEK/OSO AREA AND IMPLEMENT FINDINGS.

Conduct a detailed study of the Deer Creek/Oso area including engineering and habitat analyses to address bank stabilization, land acquisition, surrounding topography alterations, scour protection, flood proofing homes in critical areas, construction of overtopping flood control structures, culvert analysis, and flood warning.

SMOKES BROTHERS FARM

Issue

Owners of a large floodplain property (Smokes Brothers Farm) have submitted grant applications stating that they may be willing to sell the property and breach the dikes to restore a more natural floodplain. If this area has flood damage reduction opportunities, either specific to the area or cumulatively, it should be considered for acquisition (Appendix G, Figure G3).

Discussion

The Rubicon Foundation, a not-for-profit education foundation, currently owns approximately 370 acres of floodplain and uplands between RM6 and RM7. The Foundation applied for a Salmon Recovery Fund Grant to sell the property so it could be restored to more natural conditions. Some of the property currently experiences flooding, but it is unclear whether the extent of flooding is limited by levees, or whether there are additional flood storage or conveyance benefits that could be gained by the purchase of the property. In addition, another landowner owns approximately 15 acres of the downstream lobe. It is unclear what the impact of removing the existing flood control structures may have on that landowner. If any action is taken, efforts should be coordinated with the downstream landowner.

Evaluation of Alternative Actions

1. No Action
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: None.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Determine the cumulative and site-specific flood damage reduction benefits of Smokes Brothers property and seek voluntary acquisition if benefits exist.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. If future site-specific actions are identified as a result of this action, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: It is unknown what the flood impacts to the property currently are and therefore what benefits could be obtained by modifying the properties. The cost to purchase the property is approximately $1.1 million

(based on 2000 SRFBD Grant Application). Any major modifications to the property would cost at least several hundred thousand dollars more.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent. The GPP states that the County should maintain the flood storage capacity of the natural floodplain. An opportunity exists with this site to preserve or enhance flood storage.

RECOMMENDED ACTION 25: DETERMINE FLOOD DAMAGE REDUCTION BENEFITS OF ACQUIRING SMOKES BROTHERS FARM.

Determine the cumulative and site-specific flood damage reduction benefits of Smokes Brothers property and seek voluntary acquisition if benefits exist.

7.2.1 THE SOUTH FORK OF THE STILLAGUAMISH RIVER

The South Fork Stillaguamish River begins in the Cascade Mountains. From the headwaters to Robe Canyon, the river is moderately sloped reach with a narrow, generally undeveloped floodplain (RM70.4 to RM42). Just below RM42, the river enters Robe Canyon, a six-mile gorge that continues to Granite Falls. Below Robe Canyon to the confluence, the river enters a shallow sloped region to the confluence of the North Fork Stillaguamish River at approximately RM18 (RM42 to RM18).

A ***splash dam*** is a structure constructed with large diameter logs that was usually located at the upstream end of a canyon near a logging site. These dams were used to temporarily impound water in a stream during logging. When the pool was full of timber, the dam would be dynamited and the timber washed down to the larger rivers on the flood wave. This method enabled the loggers to float logs down streams that would otherwise be too small.

BLACK CREEK BRIDGE

Issue

Black Creek Bridge (Bridge No. 547) is located on the Mountain Loop Highway at RM50.2. During the flood of 1990, a massive debris slide occurred at a *splash dam* located approximately ½ mile upstream. This slide caused significant damage to the structure and future dam breaks remain possible.

Discussion

The splash dam on Black Creek is constructed of 3- to 4-foot diameter logs that lay in a crisscross pattern at the head of a rocky ravine approximately one-half mile upstream of Bridge 547 on the South Fork Stillaguamish River. This structure is approximately 40 to 50 feet high and contains an estimated eight to twelve logs.

It is believed that loggers constructed the dam in the early 1900s. For unknown reasons, the structure was never removed. Over the decades, sediment and large debris have built up and completely filled behind the structure. A significant concern exists because should the splash dam break or another debris jam break occur, large volumes of sediment would reach the South Fork Stillaguamish River potentially causing significant habitat degradation. In addition, this sediment load and debris has the potential to damage public infrastructure, especially the Black Creek Bridge. Loss of the bridge and roadway is a possibility. Because Mountain Loop Highway has periods of high volumes of traffic, there may be a public safety risk.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Moderate.
   b. Environmental Impacts: Medium. If no action is taken, the threat of complete failure still exists. Should this occur, a significant sediment load could be transported to the downstream ecosystem.
   c. Technical Feasibility: NA.
   d. Benefit and/or Cost: While there is no project cost in the no-action alternative, this does not remove or reduce the risk and therefore potential costs to the Black Creek Bridge and Mountain Loop Highway.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Remove the dam and excavate all accumulated sediment behind the structure to remove the threat.
   a. Safety Risks: Low.
   b. Environmental Impacts: High. Two methods for removal of material are possible. The sediment and debris can be removed by air (e.g., helicopter), but this method could be economically infeasible. The second method, the construction of temporary roads and use of large construction equipment, would cost less, but cause significant damage to the surrounding environment.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: In either method, the cost would outweigh the benefit. The bridge could be reconstructed for approximately $1.5 to $2 million dollars. This alternative would equal or exceed that cost.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
3. Remove one log per year.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. By removing one log each year, release of sediment would not overload the river. Black Creek would be able to reach a new equilibrium each year resulting in lower impact to the tributary. Future site-specific actions may result in potential environmental impacts. Necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. Under this alternative, natural high flows in Black Creek would remove the sediment exposed by the removal of one log over one or more winters. Once the exposed sediment had been removed, the next log would be taken out, and the cycle repeated until all logs were removed, and the channel gradient would be restored to its natural profile. Use of a helicopter to remove the logs would have the least impact.

d. Benefit and/or Cost: It is estimated to cost around $15,000 to develop a removal plan, obtain permits and coordinate with the appropriate jurisdictions. Each log removal would cost around $5,000, for a total of $30,000. Depending on flows and geomorphologic response, these costs would be spread over a period of 6-12 years. This alternative removes the flood risk, but over long period of time. In that time, the risk of a major flood occurring before project completion exists.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 26: REMOVE ONE LOG PER YEAR UNTIL BLACK CREEK SPLASH DAM DISMANTLED.

Remove one log per year on the Black Creek Splash Dam until the dam is completely dismantled.

GOLD BASIN LANDSLIDE

Issue

The Gold Basin landslide is an active slide on federal land around RM48 that contributes significant volumes of fine sediment to the South Fork Stillaguamish River. The Gold Basin Campground is a popular campsite on the opposite bank. Significant concern of human life and property loss exists if an additional large slide occurs at this location (Appendix G, Figure G5).

Discussion

The Gold Basin landslide presently occupies an area of about 200 acres. The slide originates in sediment deposits composed of sand and silt that have varied distributions vertically and laterally. This distribution results in unpredictable, very complex patterns of groundwater flow in the permeable sand and less permeable silt deposits.

Massive slope failures have occurred over the years with the most recent in 1998 and 1999. Debris flows can occur at the heads of gullies as far away as 0.3 to 0.5 miles from the river. The slopes of these gullies are oversteepened and very unstable with a high tendency for large-scale debris slides from three major lobes. These slides are a major source for fine sediment loading to South Fork and mainstem of the Stillaguamish River (GeoEngineers 2001b).

Three lobes have been identified that act independently both in terms of activity and dormancy. According the study by GeoEngineers (2001b), these lobes are different also in the terms of their direction and rate of headward expansion. Lobe 1 (upstream lobe), was active in the mid-1960s and has since stabilized and revegetated, which has eliminated the turbidity concern from this lobe for the time being.

The second lobe (middle lobe) is the most active of the three with the most recent flows occurring in 1996. The debris flow blocked the river from occupying an existing channel of forested land and caused the river to shift south towards the opposite bank. The blockage has created an area where sediment from the middle and downstream lobes (lobe 3) is deposited and stored. The *headscarp* on the middle lobe is nearly vertical and 300 to 400 feet in height. Flow from the draining stream has incised through recent deposits (GeoEngineers 2001b).

The ***headscarp*** of a landslide is the upper, beginning area of a slide.

The most downstream lobe is also very active, but is not as large as the middle lobe. As opposed to the surface flow in the middle lobe, the stream draining lobe 3 goes subsurface before resurfacing at the mouth of the lobe. A berm-like structure of highly saturated deposits has accumulated at the base of the lobe, causing additional debris to collect at the base of the slide. It is expected that a large debris flow, originating at the headscarp, will be mobilized because of the saturated sediments. In addition, evidence of slide activity upslope of this lobe is present. Because of this additional sediment source, lobe 3 may be the most significant contributor of fine sediment in this complex (GeoEngineers 2001b).

GeoEngineers stated that this complex, with the exception of the upstream lobe, has a high likelihood of failure. Although the blockage that the debris from the second lobe created is currently providing an area for additional deposition to occur, this area will most likely be unable to contain a catastrophic failure. Because the popular Gold Basin Campground is located on the opposite river bank, loss of human life and property is possible should a failure occur.

This slide is one of two large slides in the Stillaguamish Basin that are causing significant downstream impacts due to fine sediment loading (the other is the Steelhead Haven Slide on the North Fork, discussed on Page 7-44). Both of the these slides are identified as projects in the Corps of Engineers Stillaguamish River Ecosystem Restoration Study, making them eligible for 65% federal funding. The Stillaguamish Tribe is pursuing action on these slides with the Corps and Forest Service in order to reduce impacts to salmon.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Moderate.
   b. Environmental Impacts: High. While all indications are that this slide is a result of natural processes, the fine sediment will continue to enter the system and reduce habitat quality for aquatic species.
   c. Technical Feasibility: NA.
   d. Benefit and/or Cost: None.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. The site is entirely on federal land so it is outside the jurisdiction of the County.

2. Close the Gold Basin Campground.
   a. Safety Risks: Low. Closing off access to the area would eliminate the threat to life.
   b. Environmental Impacts: Low. This action removes the public safety risk but does not address the environmental damage caused by the slide.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: The Forest Service would lose revenue from the campground.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
3. Work with the Stillaguamish Tribe, USFS and the Corps to ensure that any habitat restoration project also meets public safety concerns.
   a. Safety Risks: Unknown.
   b. Environmental Impacts: Low. If future site-specific actions are identified as a result of a habitat restoration project, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. This site is located on federal land and efforts by other jurisdictions are underway to develop and implement a project to reduce potential negative environmental impacts of this slide. The County's participation in this effort is through the Ecosystem Restoration Study.
   d. Benefit and/or Cost: Unknown.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 27: ENSURE STABILIZATION OF GOLD BASIN LANDSLIDE MEETS PUBLIC SAFETY GOALS.

Work with the Stillaguamish Tribe, USFS, and the Corps to ensure habitat restoration goals of the project meets public safety concerns described in this plan.

VERLOT RIVERFRONT TRACTS - PRIVATE PROPERTY

Issue

The Verlot area is located near RM45.5, approximately three river miles downstream of the Gold Basin landslide area. The area of concern is along the right bank of a one-half mile stretch of the river. Approximately ten landowners are experiencing varying levels of accelerated bank erosion and are seeking assistance from the County (Appendix G, Figure G5).

Discussion

In December 1999, a 3- to 5-year event caused accelerated erosion that claimed approximately 15 lineal feet of residential riverfront property. The resident's septic tank and water well were threatened. Under emergency authority, a log deflector was installed along the river bank of the landowner's property. Since that time, the river has continued to erode landward at this site and more significantly just downstream.

Turlo Creek Dike was constructed in 1964 approximately one-half mile upstream of the Verlot Tracts (Figure 31). This dike was originally constructed by the County to protect the Mountain Loop Highway (Page 7-66). The dike cut off a former high flow meander channel that flowed adjacent to the highway. This dike and riprapped bank section just downstream have created a hard point on the right bank of the river. At the downstream end, a natural geologic hard point (bedrock) exists on the left bank.

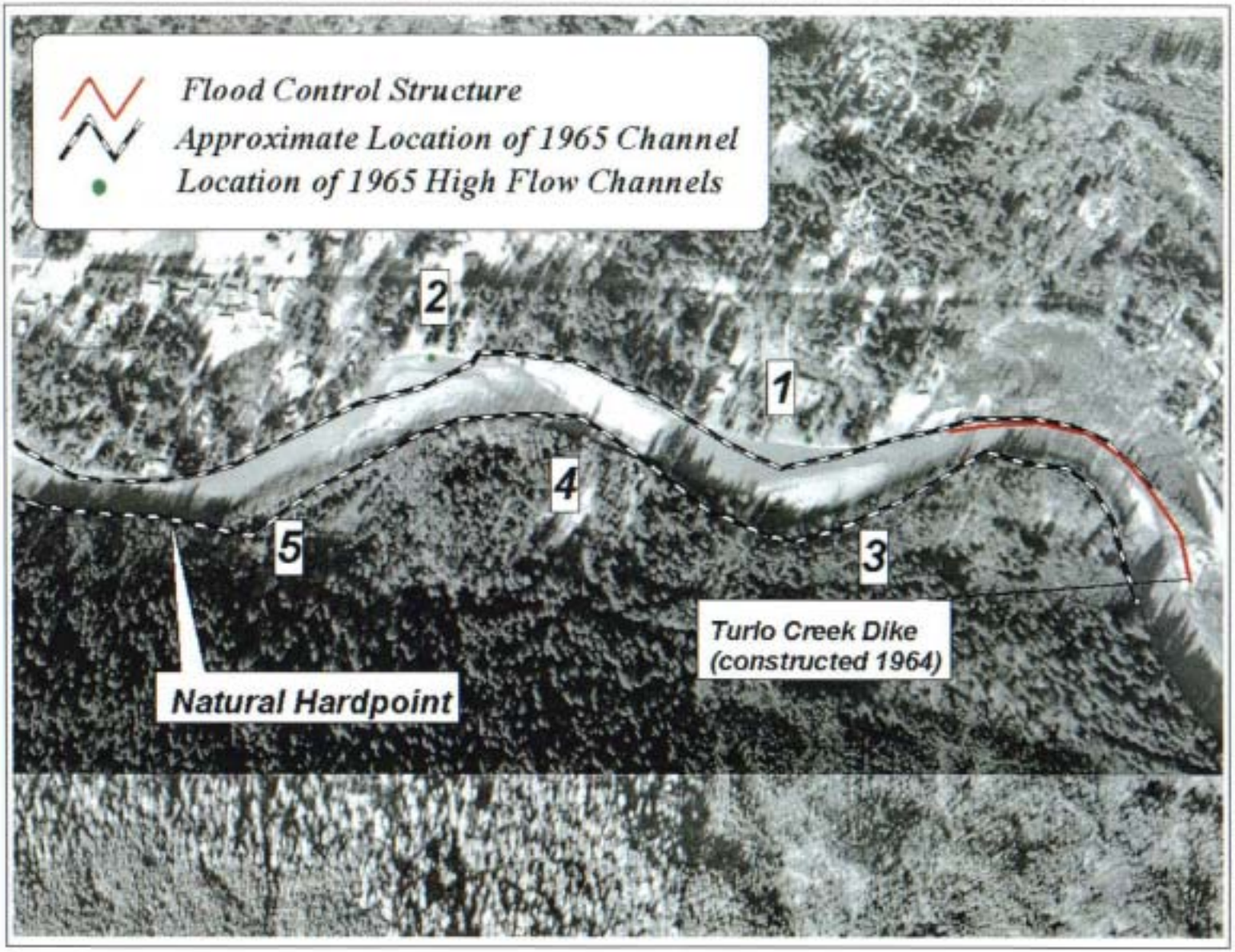
Orthophotographs of this area were obtained for the years 1965, 1969, 1978, 1984, 1991, 1998, and 2001. The 1965 channel was compared to orthophotos and changes that occurred at select numbered locations were obtained. In Table 14, erosion is indicated with a negative sign and channel filling or accretion is indicated with a positive sign. The two dots on the right bank (near locations one and two) on Figure 31 indicate where it appeared on historic maps that the river flowed during high flow events prior to 1965. The river appears to have reclaimed those high flow channels. The following table provides information on channel changes at the five locations identified on each graphic.

Table 14: Estimated Channel Changes at Select Locations in Verlot since 1965.

Location (Figure 31)	All Deltas are Relative to 1965 Channel (+/- 5 feet)						Comments
	1969	1978	1984	1991	1998	2001	
1	0	0	0	-45	-110	-110	Riprap installed in 1992/93. Between 1991 and 1998, most trees near the river were cleared.
2	0	0	-40	-70	-112	-165	Between 1965 and 1969, some vegetation was lost and a gravel bar began to develop. Between 1978 and 1984 the bar continued to develop. From 1984 to date, bank has eroded at a rate of approx. 18 feet/year. Riprap installed in 1998/1999.
3	+50	+75	+80	+85	+85	+90	
4	0	+25	+30	+30	-50	-93	
5	+65	+135	+135	+135	+150	+150	Increased vegetation on accreted area.

The Turlo Creek Dike at the upstream end and a natural hard point at the downstream end appear to be the control points for river in this reach. The channel appears to have remained relatively stable with the exception of minor accretion on the right bank until the 1991 orthophotograph. Two floods occurred in November 1990 (estimated 30-year events) that, to date, are the largest floods on record for the Stillaguamish River. Following the 1990 events, additional severe flooding occurred in 1995 (est. 10-year event), 1996 (est. 15-20 year event), and 1997 (est. 5-year event) after which accelerated erosion was observed in the reach.

Figure 31: Channel Changes in Verlot Reach (1965 channel traced to 2001 orthophoto).



In January 2000, the North Pacific Research (NPR) organization conducted a River Bank Stability Study at the expense of a local resident. NPR indicated that the river appeared stable in this reach until the 1990s. NPR concluded that the accelerated erosion was due in part to the build up of a gravel bar between locations four and five on the above graphics. NPR was unable to determine the cause of the bar's development, but indicated it may be responsible for the apparent change in flow path. NPR recommended the long-term approach to address the erosion in this area was from a reach perspective (from Turlo Creek Dike to the natural geologic hard point) that would require the participation of multiple property owners.

In April 2000, emergency bank stabilization work was conducted in which a log deflector was installed. This effort cost approximately $4,000, of which $1,600 was reimbursed to the landowner through the County's Cooperative Bank Stabilization Program.

In December 2000, the County met with many of the landowners affected by the rapid bank erosion and possible solutions were discussed. The County asked that the residents in the area organize and work together to address the bank erosion over several properties. The County considered providing hydrology and hydraulic modeling that could be used to develop a design and for permit submittals once the community submitted a Cooperative Bank Stabilization Program application that was signed by all the landowners in the affected reach. To date than application has not been submitted, as not all property owners want to pursue this effort.

In February 2002, the largest flood since the 1990 event occurred on the Stillaguamish River. South Fork flows were particularly high during this event because a weather front stalled over the Cascade Mountains near the origination of the South Fork headwaters. Based on provisional flow data, this flood was unofficially designated a 25-year event by the USGS (2002). Residents in the Verlot area indicated at least an additional 20-foot loss landward of property near Point No. 2 on Figure 31.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Low.
   b. Environmental Impacts: Moderate. Accelerated erosion will continue.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: NA.
   e. Consistency with Applicable Land Use Plans Regulations: Consistent.
2. Voluntary acquisition of affected properties and/or removal or relocation of structures. This would permanently remove the risk
   a. Safety Risks: None.

b. Environmental Impacts: Low.

c. Technical Feasibility: Feasible. However, conversations with property owners indicate that few would be interested in this option.

d. Benefit and/or Cost: To completely remove the continued risk of loss due to bank erosion, homes along the entire bank may need to be purchased. Costs for a buyout of lots at immediate risk (three to five lots) would likely exceed $500,000. Without a complete buyout, the erosion threat still exists to nearby properties. Additional analysis would need to be completed to determine prioritization of lots to be voluntarily acquired.

e. Consistency with Applicable Land Use Plans Regulations: Consistent.

3. When requested by community through Cooperative Bank Stabilization Project, work cooperatively with community to resolve bank erosion issues on a reach basis.

a. Safety Risks: Low.

b. Environmental Impacts: The impacts would vary depending on the alternative selected. A reach approach concurs with the National Marine Fisheries Services suggested criteria for sites that could be considered for bank stabilization, which would make it more plausible to obtain federal approval under the Endangered Species Act. If future site-specific actions are identified as a result assistance to this community, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

c. Technical Feasibility: Feasible. Addressing accelerated bank erosion on a reach basis is required as individual fixes will not be fully effective because of the dynamics of the river. Addressing the sediment loading from Gold Basin landslide upstream of this site should be taken into design consideration. This river has minimal opportunity to continue to meander and riprap has been installed both upstream and downstream of the reach in question.

d. Benefit and/or Cost: Unknown. Anticipated cost for completing additional community outreach, initial design, survey work, hydrology, and hydraulics engineering work is estimated at $150,000.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent. All properties in question are out of the floodway on a high terrace.

RECOMMENDED ACTION 28: WHEN REQUESTED BY ROBE VALLEY COMMUNITY THROUGH COOPERATIVE BANK STABILIZATION PROGRAM, WORK COOPERATIVELY TO STABILIZE BANK.

After submittal of a Cooperative Bank Stabilization Program application, work cooperatively with the Robe Valley Community to stabilize reach and reduce accelerated bank erosion in a manner consistent with local, state, and federal law.

ROBE HILL DIKE

Issue

Robe Hill Dike (near RM42) is located on the right bank of the South Fork Stillaguamish River. The dike was constructed in the mid-1960s to provide protection to the bank and Mountain Loop Highway. The channel has since incised and shifted away from the structure, reducing or perhaps eliminating its usefulness (Appendix G, Figure G5).

Discussion

The Robe Hill Dike, approximately 700-feet-long, is overgrown with vegetation and is not maintained by the County. It was originally constructed by the Corps to protect the Mountain Loop Highway embankment that had been threatened after a major flood event. The river has since incised, mixed fir and deciduous trees have grown on the bank, and no vehicle access is currently possible. A natural oxbow slough exists to the north of this structure adjacent to Mountain Loop Highway.

The Corps transferred responsibility for the Robe Hill Dike to the County after its construction. The County was provided a perpetual easement in 1964 by nearby property owners to access the dike to transport material with the appropriate machinery to and from the structure for reconstruction, repair, or maintenance purposes.

In 1988, Snohomish County maintenance crews recommended that the structure be abandoned, as it was no longer functioning as originally designed because of natural channel changes.

Evaluation of Alternative Actions

1. No Action. The County would continue to legally own the structure but not actively maintain it.
   a. Safety Risks: None.
   b. Environmental Impacts: Moderate. Robe Hill Dike limits fish access to slough.
   c. Technical Feasibility: NA.
   d. Benefit and/or Cost: NA.
   e. Consistency with Applicable Land Use Plans and Regulations: Not consistent. If no action is taken, then the structure will not be in compliance with Corps' standards.
2. End formal maintenance agreement on the dike and determine whether to remove, modify, or leave dike as is.
   a. Safety Risks: None.

b. Environmental Impacts: Low. The feasibility of reconnecting the cut off side channel to improve habitat should be considered. If future site-specific actions are result in potential environmental impacts, necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

c. Technical Feasibility: Feasible.

d. Benefit and/or Cost: Although no regular maintenance has been performed on this structure, officially abandoning it would remove the County from future potential liability.

e. Consistency with Applicable Land Use Plans Regulations: Consistent.

3. Rehabilitate structure to conform to current Corps standards.

a. Safety Risks: None.

b. Environmental Impacts: Moderate. Corps standards require the removal of all woody vegetation currently on the structure and construction of vehicle access to the site.

c. Technical Feasibility: Feasible. The natural channel changes that have occurred since its construction in the mid-1960s have removed the threat to public infrastructure.

d. Benefit and/or Cost: Costs to rehabilitate the structure would be substantial. However, the dike is not providing flood damage reduction benefits currently, nor would the rehabilitation add any. The cost of rehabilitating the structure would far exceed the benefit returned, as it is no longer protecting County infrastructure.

e. Consistency with Applicable Land Use Plans Regulations: Consistent.

RECOMMENDED ACTION 29: END FORMAL MAINTENANCE AGREEMENT ON THE ROBE HILL DIKE AND DETERMINE WHETHER TO REMOVE, MODIFY, OR LEAVE DIKE AS IS.

End formal maintenance agreement on the Robe Hill Dike and determine whether to remove, modify, or leave dike as is because it is no longer functioning as originally intended.

7.2.2 THE MAINSTEM OF THE STILLAGUAMISH RIVER

The Mainstem Stillaguamish River begins in Arlington where the North and South forks converge. This stretch of the river is a flat floodplain that is primarily used for agricultural activities.

FLOOD WARNING FOR MAINSTEM RESIDENTS

Issue

Currently the City of Stanwood uses the Snohomish County gage installed at confluence of the North and South forks to warn area residents of impending flooding. This gage provides approximately 12 hours notice to area residents of impending floodwaters. Improved flood warning is required to provide more specific timing information to Stanwood on impending floods.

Discussion

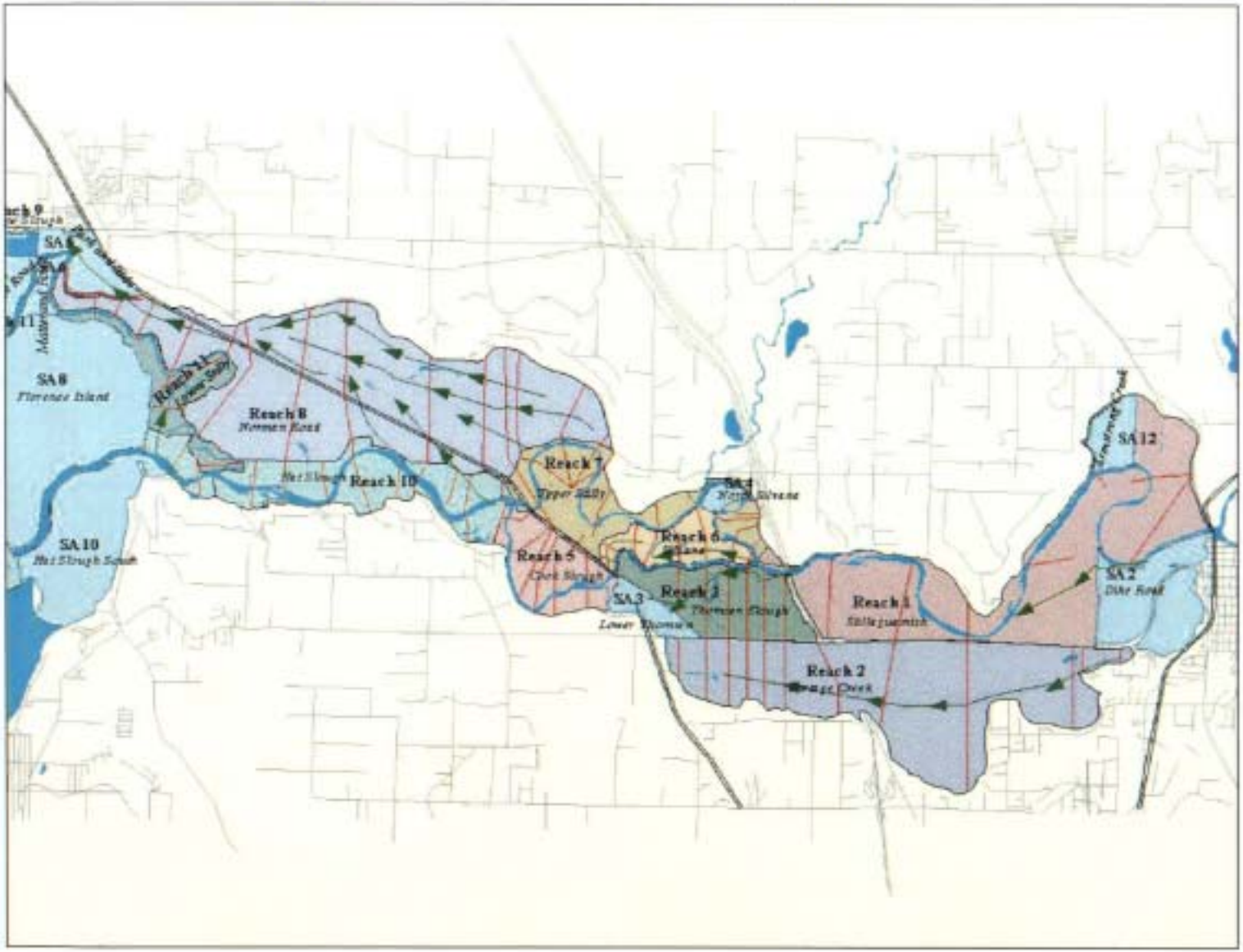
Stillaguamish River floods are very flashy. As described in previous chapters, floods are usually driven by rain-on-snow events during which heavy snowfall is followed by wind and rain. This rapid melt flows westerly through the North and South forks to the confluence at Arlington. Flow continues down the mainstem and overtops the right banks of Hatt Slough and the Upper Stillaguamish River. The floodwaters that leave the main river channel flow north and west along Pioneer Highway until they reach the Stanwood area, where the existing lagoon levee system causes the floodwater to pond quickly south of SR532 (Figure 32). Once the waters reach the Park and Ride area (commuter parking area) east of the lagoon, they rise very rapidly.

The City of Stanwood Fire Department staff monitors floodwaters in the lower basin. During flood events, Stanwood staff is in constant contact with Snohomish County Department of Emergency Management staff who monitor the river gages on all the County rivers and provide updates as necessary. When water overtops the Upper Stillaguamish River channel and flows down the valley, emergency response field staff provides updates to emergency staff at the fire station. Based on the content of these updates, Stanwood Fire Department staff will conduct a door-to-door warning notifying local residents of impending flooding.

When the Upper Stillaguamish River channel is overtopped, Stanwood has approximately 12 hours before floodwaters reach the Park and Ride area. Improved flood warning capabilities will allow the City and surrounding residents to be better prepared once floodwaters reach the lower basin. Improved flood warning capability would provide Stanwood more accurate information on volume and timing of floodwaters as these flows approach the city.

Making enhancements to the County's flood warning program is part of SWM's annual work plan. Two additional flood warning gages were installed on the mainstem in 2003 to provide improved warning to mainstem residents. SWM staff are working towards installation of official flood warning stations on the North and South forks as well as installation of a staff gage installed near the Park and Ride area near Stanwood.

Figure 32: Flow Patterns in Mainstem Stillaguamish Basin.



Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: None.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Install a telemetered gage on the Pioneer Highway Bridge (Bridge No. 653) to improve flood warning to downstream area residents.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. If future site-specific actions result in potential environmental impacts, necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: Estimated installation cost is $5,000 for material and staff. Annual costs (assuming 4 hours staff time per month/gage) are estimated at $1,200. Improved flood warning to area residents would allow them to move valuables, including vehicles, out of harm's way, which would result in reduced flood damage costs. In addition, because the new Stanwood fire station is being constructed, steps can be taken to connect the telemetered gage at the new location, providing emergency response staff real-time flow information at a far less cost than at the current location.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 30: PROVIDE IMPROVED FLOOD WARNING ON THE MAINSTEM.

Install a telemetered gage on the Upper Stillaguamish River channel to improve flood warning to the City of Stanwood, Stillaguamish Flood Control District, and area residents.

DIKE ROAD DIKE AREA

Issue

Dike Road Dike is located on the left bank of the Stillaguamish River downstream of the confluence of the North and South Forks. In 1990, this flood control structure overtopped and floodwaters flowed westerly over land before discharging back into the main channel. The threat of an avulsion was evident as the flow path followed an abandoned flow channel, threatening to disconnect properties to the north (Appendix G, Figure G6).

Discussion

Dike Road Dike is one of the 26 Works Projects Administration projects still owned and maintained by the Corps. This 5,300 lineal foot structure was constructed between 1935 and 1937. The County constructed a road and peanut berm (mound of soil on bank) on top of the dike, both of which are the responsibility of the County. The dike has been repaired a number of times by both the Corps and the County since its construction. Cost information dating back to the 1990 floods is documented.

Table 15: Estimated Repairs Costs for Dike Road Dike, Berm, and Road Since 1990.

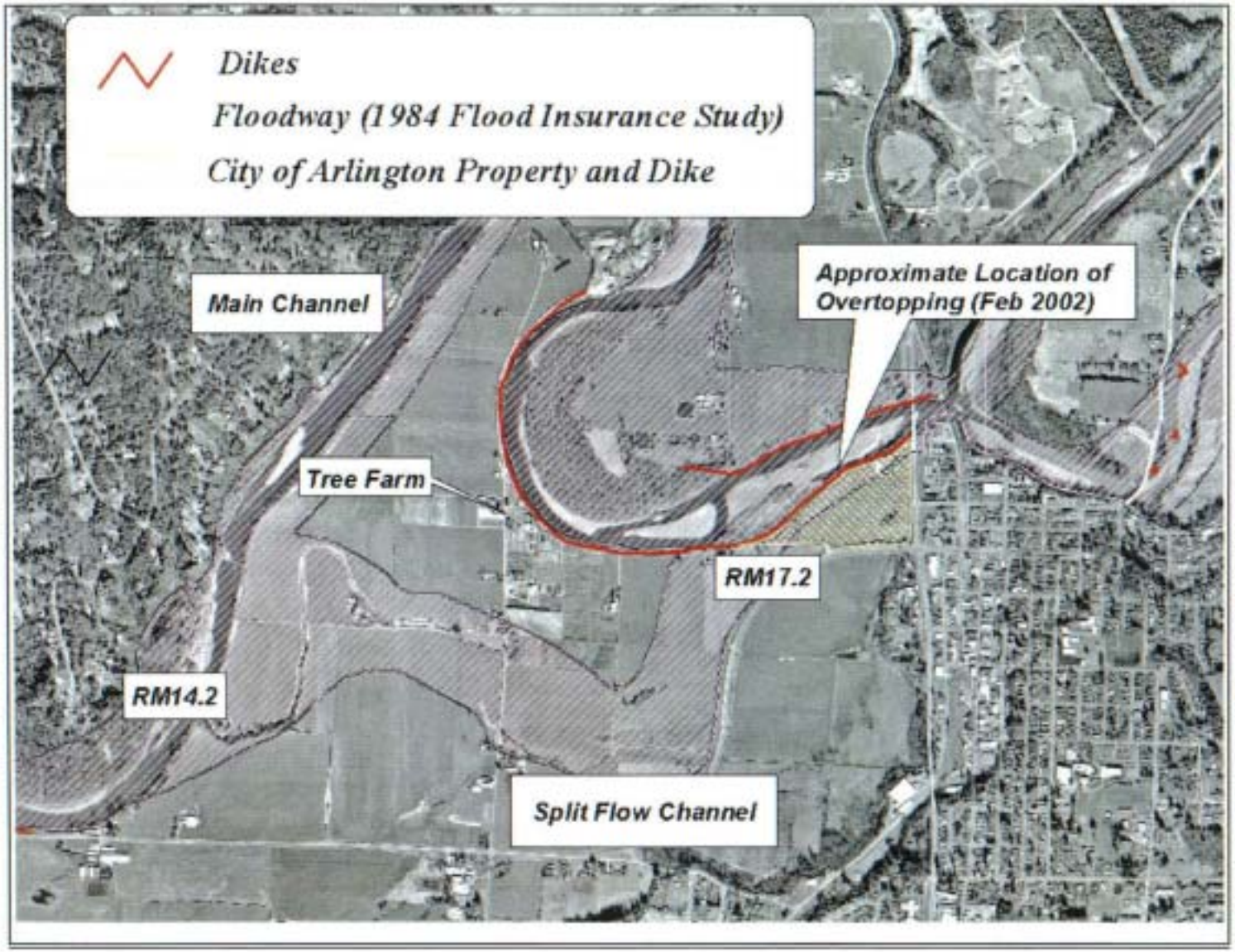
Year	Estimated Cost ($)	Comments (not all costs indicated below were paid for entirely by the County)
1990	10,366	Damaged by a 25-year event. Emergency repair work included equipment, crushed rock, and 5-man rock (large boulders).
1991 - 1992	8,000	FCAAP grant awarded to repair depressed section of embankment and install a rock filter drain through embankment. Estimate to repair entire structure was $36,994 following floods of 1990, but because of limited funding, only the most severely damaged portion of dike was repaired.
1995	20,665	Road damage from floods of 1995 and remnant 1990 damage.
Annual Costs	3,000	Estimated based on annual costs for other County-owned structures.

In the Flood Insurance Study completed by the Corps (FEMA 1982), a split-flow channel (possible location of where water could flow outside the river channel) was identified just below the confluence of the forks (Figure 33). The Corps determined that flows over 66,000 cfs would overtop the dike and flow from RM17.2 to RM14.2 where they would reconnect with the main channel again. The actual flow path may not be reflected accurately in the FIS.

The November 1990 floods provided an opportunity to verify the Corps' estimated overtopping. Flows from those floods neared 65,000 cfs. The stage at Arlington reached 20.0 feet, which is the highest stage in recorded history on the Stillaguamish. Significant overtopping occurred throughout most of the dike's length and as indicated in Table 15 above, significant costs to repair the structure were incurred. A tree farm and several residences were inundated. The tree farm suffered significant financial losses and much of its inventory was lost during this event.

Gage readings on a more recent (February 22, 2002) flood event were recorded at 19.5 feet at Arlington, just 0.5 feet shy of the 1990 flood. Significant overtopping occurred along the Johnson Levee (now owned by the City of Arlington), which is upstream of the County-owned portion of Dike Road Dike structure. The river began to recede almost as quickly as it crested so no substantial damage was incurred.

Figure 33: Dike Road Dike and Split Flow Channel on the Mainstem Stillaguamish.



Three boils (areas where the river water breaks through from the riverside to the landside of a dike) were found near the tree farm, but no significant damage occurred during the February 2002 flood event. The most significant threat from the 2002 flood and from the 1990 flood was the risk of a channel avulsion through the Split Flow Channel denoted in the 1982 FIS study (Figure 33). In the 1990 floods, water followed this pathway until reconnecting with the river at RM14.2. Because the crest occurred so quickly in the February 2002 flood, the overtopping flows were not significant enough to flow through the Split Flow channel. Overtopping flow ponded in the fields to the south and areas just west of Dike Road. Should an avulsion occur, life and property would be at risk.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: None.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Conduct an avulsion risk study.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. If future site-specific actions are identified as a result of this study, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. Hydraulic modeling and additional analyses would be required to evaluate overtopping frequency, flow, velocities, and impacts.
   d. Benefit and/or Cost: Estimated cost of study is $40,000. The County has contributed significant funds to the maintenance and repair of the Dike Road Dike and berm. Costs to repair this structure and the County road should an avulsion occur would likely exceed $1 million dollars.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 31: CONDUCT AN AVULSION RISK ASSESSMENT OF THE DIKE ROAD DIKE AND BERM AND IMPLEMENT FINDINGS.

Conduct a study to determine the risk of an avulsion through the abandoned channel behind the Dike Road Dike and berm and develop solutions to prevent such an event from occurring. Include City of Arlington to address that portion of the dike they own.

CITY OF STANWOOD/LOWER MAINSTEM STILLAGUAMISH

Issue

The City of Stanwood (COS) is vulnerable to flooding from the Skagit River to the north, the Stillaguamish River to the south, and tidally from the west. Possible solutions were studied under the Corps-led Section 205 Small Flood Study over the last few years and the results of that work are incorporated into this basin-wide comprehensive Stillaguamish River Flood Plan (Appendix G, Figure G7).

Discussion

Stanwood is vulnerable to Skagit flooding at an estimated 20-year event. In 2003, the Corps and local jurisdictions upgraded the left bank levee along the Skagit River that would impact the COS. Prior to that upgrade, this levee was the second most likely failure point on the Skagit River system. The Corps preferred alternative to address this risk is to elevate Big Ditch Road to protect the COS from the 100-year Skagit River flood event.

Tidal threats were also evaluated as part of the Section 205 Small Flood Study. However, hydraulic modeling coupled with a review of the history of the COS area indicated that the COS was at greater risk from flooding by the Stillaguamish River. Sea dikes west of the COS are built to elevations from 11-ft up to 14-feet (NGVD-29). This would protect the COS from an approximate 17-ft to 20-ft tidal event, respectively, which is greater than the predicted 100-year tidal event. The estimated 100-year tidal event is approximately 10-ft (NGVD-29), which means that the existing dike structure is at least one foot or more above the predicted 100-year tidal event.

COS is vulnerable to Stillaguamish River flooding at an estimated 30-year event. Modeling conducted as part of the Section 205 Small Flood Study indicated that floodwater levels in the Park and Ride area (commuter area) are estimated to be three feet higher than existing regulatory levels established in 1980. These results indicate that COS's wastewater treatment plant (WWTP) lagoons and the COS may be vulnerable to Stillaguamish flooding.

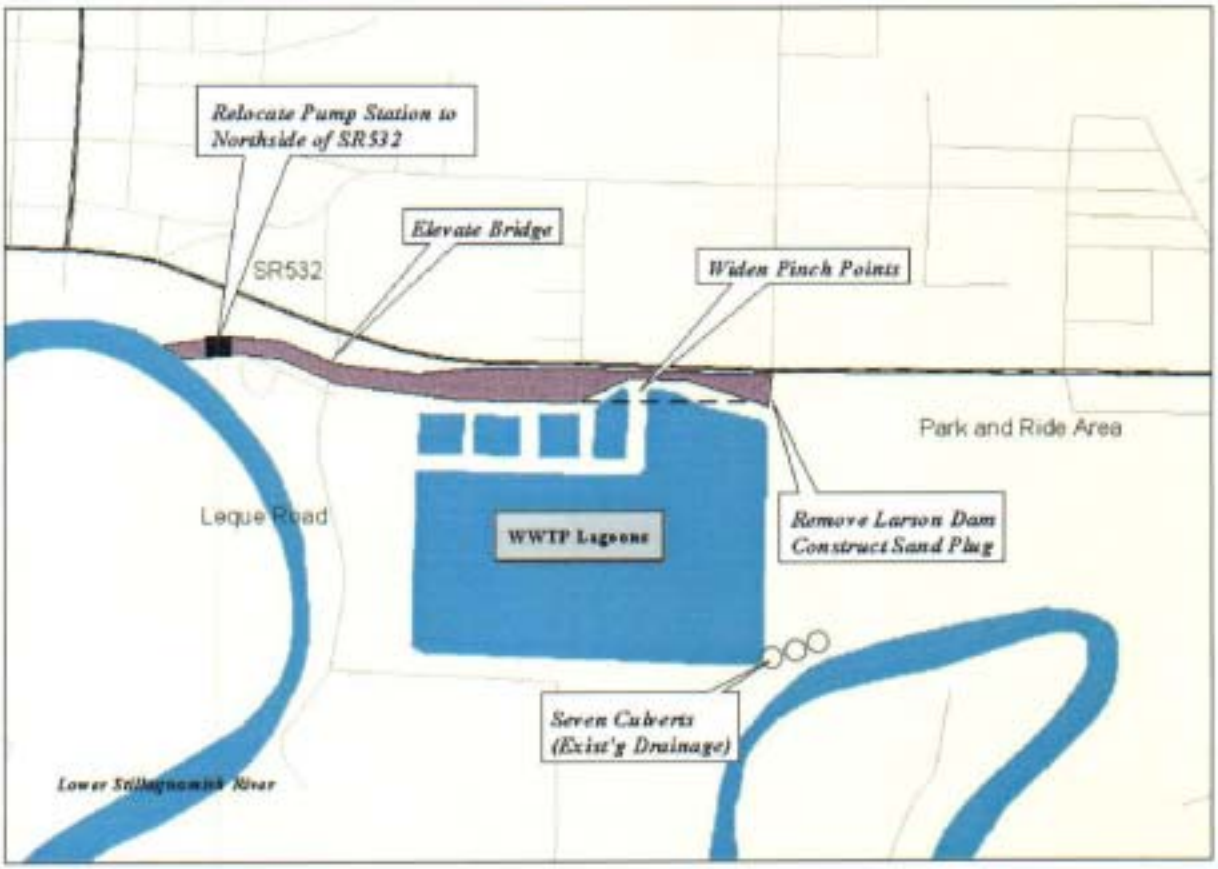
Hydraulically Preferred Alternative for Stillaguamish River Flooding

The hydraulically preferred alternative to reduce flooding potential from the Stillaguamish River involves reopening Irvine Slough as a floodwater conveyance channel. Irvine Slough (slough) varies in width from 85-foot wide to 150-foot wide channel that is sandwiched between the COS WWTP and State Route 532 (Figure 34). A pump station at the west end of the slough maintains water levels in the slough at a (-) 2-ft elevation (NGVD-29) so that gravity-driven stormwater from the

COS can drain properly into it. The pumps then discharge the stormwater into the Old Stillaguamish River channel. In addition, a berm (a.k.a Larson Dam) with a 3-ft culvert through it was constructed at the east end of the slough following the floods of 1990. In the 1980s and 1990s, potable and waste water pipes were placed in the south (left) bank parallel to the entire slough. The Leque Road Bridge crosses the slough approximately 200-feet upstream of the pump station. This bridge provides access to the homeowners on Leque Island.

This hydraulically preferred alternative would include relocating the pump station north of SR532, elevating Leque Road bridge, removing "Larson Dam" and replacing it with a sand plug, and making other improvements to the slough channel. This alternative would allow the 2,500-foot slough to become tidally influenced with the sand plug breached every 3 to 5 years on average.

Figure 34: Hydraulically Preferred Alternative for Reopening Irvine Slough.



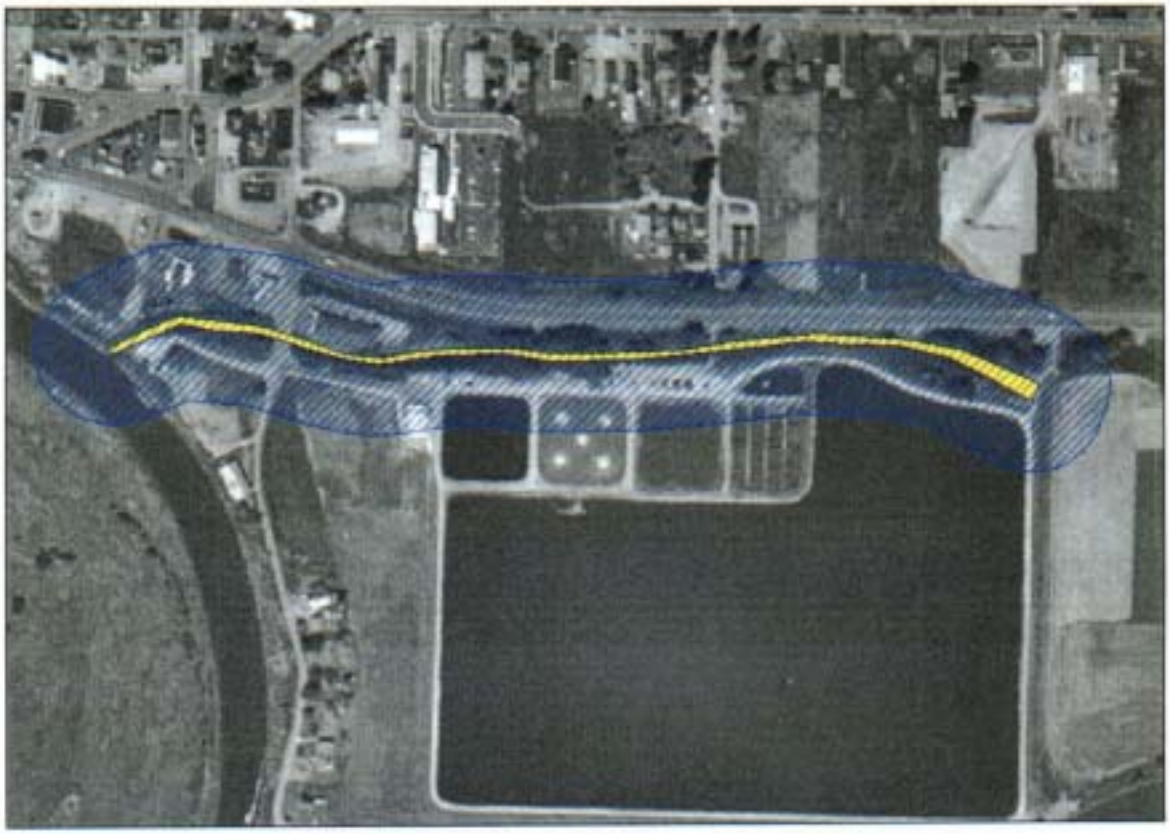
The COS is generally protected by SR532, which acts as a levee during Stillaguamish River flood events. For areas that are vulnerable to flood water, such as Marine Drive near the Park and Ride, the COS has standard procedures they implement to protect it during flood events that are cost effective.

While reopening Irvine Slough provides the greatest flood reduction in the area, this alternative has significant challenges for the partners. The estimated costs developed in the Section 205 were approximately $3 million dollars, but recent estimates indicate this alternative would top out at nearly twice that amount.

In addition to the high cost of this alternative, reopening the slough to tidal influence also changes the definition of the slough itself. It is currently not considered a water of the state because of the pump station at the west end. However, if the slough were reopened, the channel would be defined as a water of the state and therefore regulated by the state. This would mean that state regulations, such as those addressing shorelines and federal regulations, such as the Endangered Species Act, would impact the land use adjacent to the channel. Shoreline regulations impact areas within 200-ft of the MLLW.

Figure 35 shows the approximate area that would be affected by the shoreline regulation. The city would be required to update its Shoreline Master Plan and the surrounding businesses would be required to adhere to the updated plan. While not impossible, it is an expensive proposition (an estimated $100,000 to update the plan). In addition, as shown on the figure, the city's WWTP is within 200-foot area, indicating that operations at the plant may be affected. Because SR532 is also within the 200-foot area, planned widening of the State Route in the future would be impacted. For these reasons, this alternative was not selected.

Figure 35: Approximate Area within 200-feet of Irvine Slough.



Other alternatives evaluated in the Section 205 study included:

1. Elevating the right bank levee system along the Upper Stillaguamish Channel where floodwater that enter the Park and Ride area originate. This proved too costly and transferred the floodwaters to downstream neighbors.
2. Construct a 400-foot channel through the "Matterand" lobe or Twin City Property coupled with reopening the slough. This alternative lowered water levels near the slough by allowing floodwater to enter Puget Sound upstream of the slough. This alternative was not selected because TCF's has a wastewater pipe that bisects the property raising access issues. In addition, agriculture use would be impacted, which was not an acceptable option for the partners.
3. Construct a 100-foot bypass around the pump station with a sand plug or similar control structure at the upstream end. This option proved too costly due to utilities (bridge, pipes), regulatory issues (e.g., a Shoreline permit would be required to rebuild the sand plug after each breach) and there were concerns about the impact to surrounding businesses.
4. Construct a ring dike around the City of Stanwood. This option proved too costly financially and to surrounding farmers.

Scaled-Down Irvine Slough Alternative Refined after the 205 Study

The COS, FCD, and County have continued to work collaboratively to develop a solution that provides post-flood drainage for the FCD, local farmers, and surrounding residents. In addition, the alternative developed provides flood protection for the COS without impacting the slough's designation or the COS's stormwater drainage infrastructure. This alternative would be funded equally among the partners either through cash or in-kind contributions and includes the following:

1. Install a flood control structure on Larson Dam to convey additional floodwater during flood events ($50,000 to $100,000);
2. Investigate installing a minimum of two additional pump stations to ensure COS proper is not flooded when Irvine Slough is being used as a floodwater conveyance channel ($150,000 to $300,000 for two);
3. Install two additional pumps on existing pump station at west end of Irvine Slough. Currently the capacity of each pump is 30-cfs ($25,000 to $50,000 each). Investigate upsizing all four pumps to their maximum capacity;
4. Install a 24-inch or larger bypass pipe or open channel around the pump station to supplement conveyance through the slough ($75,000 to $150,000);
5. Construct an flood control structure of sufficient size for rapid post-crest drainage adjacent to the "7 tubes" at the southeast corner of the WWTP ($200,000 to $300,000); and,
6. Determine how to minimize damages to the levee upstream of the "7 tubes" on the right bank of the Old Stillaguamish River. Have the levee section certified to Corps' standards so it is eligible for federal disaster assistance. This may include strengthening the existing levee or replacing it with an overtopping one ($100,000 to $200,000).

Evaluation of Alternative Actions to Address Skagit River Flooding

1. No Action/ Do Nothing
   a. Safety Risks: Unknown. Should a breach occur on the South Fork of the Skagit River, successful flood fighting would be challenging due to volume of water.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible.
   d. Benefit vs. Cost: Should the levee breach and floodwater reached the city of Stanwood, costs are estimated to be $20 million or more.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Elevate Logan Road for use as a cross dike and construct a sand plug to discharge flood flows to Skagit Bay.
   a. Safety Risks: Low.
   b. Environmental Impacts: Medium. Because the property boundaries "zigzag", the levee would have a similar pattern. This would increase the likelihood of negative environmental impacts.
   c. Technical Feasibility: Feasible. While this option is technically feasible, boundary line issues and multiple easements make this option challenging. This option does not increase floodwater levels to neighborhood residents.
   d. Benefit vs. Cost: Low. Estimated cost is $2.5 million to construct a levee that would protect the city from a 100-year Skagit River flood event. Benefits for this size flood are estimated at or around $20 million.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
3. Elevate Big Ditch Road for use as a cross dike and construct a sand plug to discharge flood flows to Skagit Bay.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. Existing footprint of road would be widened, which may impact some adjacent agricultural land. Currently used as a low service access road for Washington State Fish and Wildlife. A tidegate structure is located at the at the far west end and would not be impacted by this action.
   c. Technical Feasibility: Feasible. The levee can be tied into existing County road on the east end. It includes elevating an existing east/west road from 2-ft (NGVD29) to 9-ft (NGVD29) to provide up to 100-year flood protection to Stanwood. Hydraulic modeling conducted by the Corps indicated that this option did not increase floodwater levels to neighborhood residents.
   d. Benefit vs. Cost: Construction costs estimates are from $600,000 to $1.6 million. Benefits are estimated at $20 million for a 100-year event assuming that the city would not flood.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 32: ELEVATE BIG DITCH ROAD TO PROVIDE FLOOD PROTECTION TO THE CITY OF STANWOOD FROM THE SKAGIT RIVER.

This action includes elevating an existing low service road from 2-ft to 9-ft (NGVD-29) and constructing a sand plug or similar flood control structure at the west end of the levee to protect Stanwood from Skagit River floodwaters.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: A 100-yr flood on the Stillaguamish or Skagit would flood Stanwood resulting in estimated damages near $20 million.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Implement the hydraulically preferred Irvine Slough alternative.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. If future site-specific actions are identified as a result this study, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible. Work with study partners in the Section 205 Small Flood Study to complete the feasibility study. Develop viable, economical solutions to reduce the potential of City flooding and improve post-flood drainage for the Flood Control District.
   d. Benefit and/or Cost: Actions taken would protect the City of Stanwood and improve drainage on the floodplain benefiting flood control structures and agriculture. These benefits (reductions in flood damages) would outweigh the anticipated $6 million cost.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. Applicable federal, state, and local regulations dependent on alternative selected.
3. Construct a ring levee around Stanwood.
   a. Safety Risks: Low. Levee may give sense of security to those residing behind structure, which may result in greater losses should a breach occur.
   b. Environmental Impacts: High.

c. Technical Feasibility: Not feasible. May increase floodwater levels for upstream residents and would not provide drainage relief to the Flood Control District. Significant property boundary, utility, environmental, and regulatory issues exist.

d. Benefit vs. Cost: This alternative does not meet cost:benefit.

e. Consistency with Applicable Land Use Plans and Regulations: Inconsistent. Current county plans place high value on farmland. This action would negatively impact farmland.

4. Construct a bypass south of existing cross levee through Twin City Foods (TCF) property with a sand plug on the Old Stillaguamish River channel side only.

   a. Safety Risks: Low.

   b. Environmental Impacts: Medium.

   c. Technical Feasibility: Feasible. New cross levee would be approximately 1450-feet in length. Sand plug installed at upstream end with South Pass end opened for tidal influence. This option works more effectively when combined with Irvine Slough improvements. Issue with existing TCF wastewater pipe approximately 4-feet below ground through center of property. Pipe must be protected and accessible.

   d. Benefit vs. Cost: Costs estimated at $1 million. Costs with Irvine Slough improvements total $7.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

5. Construct a bypass north of existing cross levee through Matterand property with a sand plug on the Old Stillaguamish River channel side only.

   a. Safety Risks: Low.

   b. Environmental Impacts: Medium.

   c. Technical Feasibility: Feasible. New cross levee would be approximately 1150-feet in length. Sand plug installed at upstream end with South Pass end opened for tidal influence. This option works more effectively when combined with Irvine Slough improvements. Issue with existing TCF wastewater pipe approximately 4-feet below ground through center of property. Pipe must be protected and accessible.

   d. Benefit vs. Cost: Costs estimated near $1 million for this action alone. When combined with Irvine Slough improvements costs were estimated above $7 million.

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

6. Construct a bypass north of existing cross levee through Matterand property with a sand plug on the South Pass side and on the Old Stillaguamish River channel side.

   a. Safety Risks: Low.

   b. Environmental Impacts: Medium.

c. Technical Feasibility: Feasible. New cross levee would be approximately 1150-feet in length. Issue with existing TCF wastewater pipe approximately 4-feet below ground through center of property. This option works more effectively when combined with Irvine Slough improvements. Pipe must be protected and accessible. Sand plug installed at both ends to provide continued access to agriculture land on lobe, therefore no habitat benefit.

d. Benefit vs. Cost: Estimated cost is $1.7 million. When combined with Irvine Slough improvements costs were estimated above $7 million.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

7. Construct a berm along SR532 from Marine Drive to Leque Road and continue structure along left bank of Irvine Slough.

   a. Safety Risks: Low.

   b. Environmental Impacts: Low.

   c. Technical Feasibility: Feasible. While this alternative is feasible, neither the City of Stanwood nor FCD would support it for several reasons. The primary goal of the preferred plan chosen in this Section 205 Small Flood Study is to provide flood relief to Stanwood and to improve drainage for Stillaguamish FCD residents. While this option may provide flood relief to Stanwood, it does not provide any drainage relief to the Stillaguamish FCD.

      Additionally, this alternative may cause water to stack up and possibly overtop the wastewater treatment plant lagoon levees, which could potential impact residents on Leque Island. Additional analysis would need to be completed to guard against this potential.

      In addition to residential issues, this alternative negatively impacts the City of Stanwood stormwater drainage system. Should floodwater enter the slough, gravity-fed tidegates designed to release stormwater to the slough would be rendered inoperable. This has the potential of causing stormwater flooding to Stanwood.

      This option does not allow for restoration of any part of the natural floodplain ecosystem. Construction of a levee on the left bank of the slough does not improve the habitat conditions in the area.

   d. Benefit vs. Cost: Cost of 2,000 feet of jersey barriers for installation along SR532 between Leque Road and Marine Drive estimated at $72,000 (estimated 240 barriers at $300/barrier. Nearly 600 feet of rehabilitated levee would be required along the right bank of Irvine Slough at an estimated cost of $500,000 (assuming $830/L.F)

   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

8. Implement the scaled-down solution that includes improvements to Irvine Slough to aide in post-flood drainage, construction of a flood control structure adjacent to the "7-Tubes," and FCD levee improvements.

a. Safety Risks: Low.

b. Environmental Impacts: Low. If future site-specific actions are identified as a result this action, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.

c. Technical Feasibility: Feasible. This option is supported by the City of Stanwood, the Flood control District and the County.

d. Benefit and/or Cost: Cost is estimated between $600,000 and $1.2 million to implement the six components. Specific items could be initiated on different timelines as funding sources become available, which could reduce the amount of cash contribution required by the three partners.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent.

RECOMMENDED ACTION 33: IMPLEMENT SCALED-DOWN SOLUTION WITH DEFINED ALTERATIONS TO IRVINE SLOUGH AND CONSTRUCT A FLOOD CONTROL STRUCTURE ADJACENT TO TH E "7-TUBES" FOR POST-FLOOD DRAINAGE.

Action includes alterations to Larson Dam and to the existing pump station at the west end of Irvine Slough. It provides additional conveyance around the pump station and increases the COS pumping capacity. Also improves FCD levee system and provides for a flood control structure near the "7-tubes" to provide increased post-flood drainage.

PORTAGE CREEK

Issue

The Snohomish County Parks and Recreation Department currently owns the Portage Creek Wildlife Reserve. Using this area to reduce flooding from the Stillaguamish River is not possible because of its location. Opportunities may exist to use this area as flood storage for urban runoff from the headwaters of the creek provided restoration activities taking place in this system are not compromised (Appendix G, Figure G6).

Discussion

In Stilly Flood Plan Advisory Committee meeting discussions, members encouraged the use of Portage Creek and the Wildlife Reserve to reduce flood damages from urban stormwater runoff, particularly during high precipitation events. Most of the headwaters to this creek are in the City of Arlington's Urban Growth Area in which urban density development is planned. Portage Creek is subject to backwater

flooding from the mainstem floodplain. Flood flows on the mainstem once accessed Portage Creek directly until SR530 was constructed.

Portage Creek is another project identified for habitat restoration in the Corps' Ecosystem Restoration Study (one of ten total). Over six miles of the middle and lower reaches of Portage Creek are planned for restoration to enhance channel complexity and riparian habitat (Corps 2000). Flood reduction opportunities to build upon this proposed work should be pursued.

Evaluation of Alternative Actions

1. No Action.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: None.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. Although no action is consistent with current County regulations, Goal NE3, Objective D.12 of the General Policy Plan encourages consideration of programs that strive to achieve no net gain of water run-off rates. This action would not achieve that objective.
2. Investigate methods for flood hazard reduction benefits as part of the restoration activities in Portage Creek.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. If future site-specific actions result from this action, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: $200,000. This work would be combined with the efforts of the Corps to reduce costs and increase benefits.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent. This work would meet the goals and objectives of the General Policy Plan and those of this Stilly Flood Plan.

RECOMMENDED ACTION 34: INVESTIGATE METHODS FOR FLOOD HAZARD REDUCTION BENEFITS AS PART OF THE RESTORATION ACTIVITIES IN PORTAGE CREEK.

Determine methods to use Portage Creek for flood reduction that support on-going efforts to restore the County-owned Wildlife Reserve.

CHURCH CREEK (JOERGENSON SLOUGH)

Issue

Church Creek is one of three mainstem tributaries with urban areas in its watershed. The lower end of the creek flows over the Stillaguamish River floodplain and enters the Old Stillaguamish Channel through tide gates at the mouth. Berms are on either side of that floodplain portion of the creek. Channel aggradation in the floodplain reach due to upland sediments has and will continue to be exacerbated by upland development. Addressing this issue now will prevent longer-term problems from potentially developing. The berms that confine the creek affect how Stillaguamish floodwaters reach Stanwood, so management practices must consider the effects of both river flooding and upland runoff (Appendix G, Figure G7).

Discussion

Church Creek drains around 7,500 acres (approximately 12 square miles) of land in the lower mainstem of the Stillaguamish River. Church Creek flows southwesterly until entering the Stillaguamish River floodplain. It then turns west and joins the Old Stillaguamish River (Figure 36). Church Creek supports a coho run.

Much of the area outside the City's UGA and I-5 is zoned Rural Residential, which allows one home per five acres. Assessor data (2001) indicated that 417 parcels totaling more than 4,200 acres were still undeveloped. This could theoretically mean that more than an additional 840 homes could be constructed in this area. The lower rural densities would limit development impacts. However, associated conversion of forest to pasture and increases in impervious surfaces will cause additional impacts to the creek. Even with stormwater mitigation requirements in urban areas, flow volumes will increase, and sediment loads can also be expected to increase during the years of development.

The lower floodplain reach of Church Creek is also referred to as Joergenson Slough. The lower reach is confined between berms, and 3 tide gates at the mouth of Church Creek regulate discharge to the river. As Church Creek enters the floodplain of the Stillaguamish, sediment settles out resulting in channel bed aggradation. This is a natural process that is exacerbated by development, resulting in increases in flow and sediment loads. During high tides, the tide gates are closed so that there is no outflow or velocity, which increases the rate of sediment deposition. In addition, during Stillaguamish River flooding, floodwater flows perpendicular over the Church Creek berms and across the channel, which adds to the sedimentation issues.

Altering Church Creek's berms on either side will have an impact on flood flows from the Stillaguamish River. If the berms were lowered, flood flows would most likely reach the Stanwood Park and Ride area (commuter area) more quickly. If these berms are elevated, flood flows could stack up on the upstream end potentially

increasing flood damages to upstream residents. Alterations of these berms should consider both possibilities.

In the past, most recently in the mid- to late-1990s, the Stillaguamish Flood Control District (FCD) dredged Church Creek to remove the accumulated sediment. More recently, the FCD conducted plantings to improve the habitat and shade out some of the reed canary grass that has reduced channel conveyance. In addition, modification to the tide gates to improve fish passage and address water quality concerns is being studied. Future management of the floodplain reach of Church Creek will need to address both continued upland impacts and river flooding issues.

In addition to the tide gate modification effort, SWM's Stillaguamish Watershed Steward for the Stillaguamish River basin is leading a multi-jurisdictional, landowner-based effort to restore up to 15 sites in the watershed. To date, commitments have been received on ten of those sites. This work includes restoring fish passage through a man-made dam in the upper watershed, enhancing instream habitat conditions, providing for dry animal crossings, and restoring buffers by fencing and riparian plantings. These efforts address areas such as sediment regime, hydrology, and water quality.

Evaluation of Alternative Actions

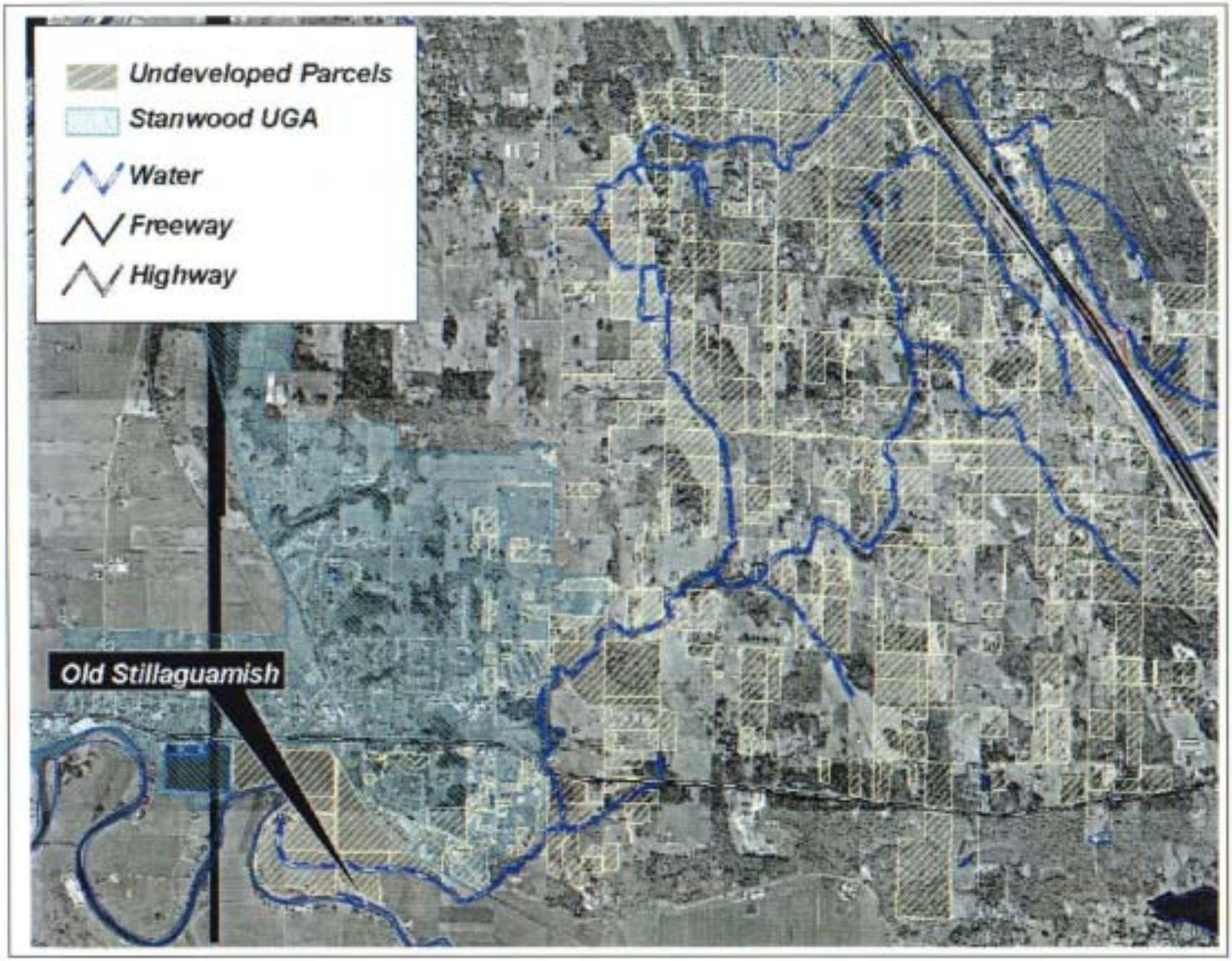
1. No Action.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low.
   c. Technical Feasibility: Feasible.
   d. Benefit and/or Cost: None.
   e. Consistency with Applicable Land Use Plans and Regulations: Consistent.
2. Investigate alternatives to best address upland stormwater impacts to lower Church Creek while maximizing flood damage reduction and habitat benefits.
   a. Safety Risks: Low.
   b. Environmental Impacts: Low. Understanding and addressing sedimentation issues will retain adequate conveyance of stormwater over time and have additional benefits for aquatic species. If future site-specific actions are identified as a result this investigation, potential environmental impacts and necessary mitigation measures will be identified and addressed through the appropriate federal, state, and local regulations..
   c. Technical Feasibility: Feasible. Development in the upper Church Creek will continue, which may result in increased flows and sediment loads that impact the lower creek.
   d. Benefit and/or Cost: An initial feasibility study to evaluate alternatives would cost from $30,000-$60,000.

e. Consistency with Applicable Land Use Plans and Regulations: Consistent. This work would meet the goals and objectives of the General Policy Plan and those of this Stilly Flood Plan.

RECOMMENDED ACTION 35: ADDRESS UPLAND STORMWATER IMPACTS TO LOWER CHURCH CREEK.

Investigate alternatives to best address upland stormwater impacts to Lower Church Creek while maximizing flood damage reduction and habitat benefits and implement findings.

Figure 36: Church Creek Watershed.



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