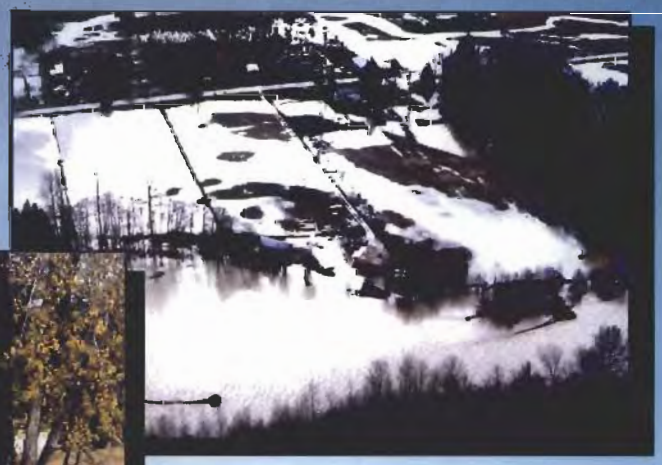
Mason County Skokomish River Comprehensive Flood Hazard Management Plan

Volume 1
February 1997



KCM

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Mason County
Skokomish River Comprehensive Flood Hazard Management Plan

Volume I

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SKOKOMISH RIVER
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

VOLUME I

FEBRUARY 1997

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RESOLUTION NO. 146-96

A RESOLUTION adopting the Mason County Skokomish River Comprehensive Flood Hazard Management Plan

WHEREAS, the Skokomish River Valley is an area of great natural beauty and rich agricultural land that has attracted people to live and work in the floodplain for hundreds of years; and

WHEREAS, residents of the Skokomish River Valley, including members of the Skokomish Tribe, have been effected by human activities in the watershed during the past decades; and

WHEREAS, extreme events, that appear to occur with increasing frequency, have devastating effects; and

WHEREAS, the overall goal of this Comprehensive Flood Hazard Management Plan (CFHMP) is to reduce hazards from frequent and infrequent events using actions that are appropriate to conditions in the Skokomish Valley; and

WHEREAS, the CFHMP is a combination of previous efforts and plans that have been developed over the last several years; and

WHEREAS, in April, 1992, the Mason County Board of Commissioners formed the Planning Advisory Committee to promote the overall goals of the project; and

WHEREAS, the Planning Advisory Committee conducted numerous public workshops wherein the Plan was discussed and public input was heard; and

WHEREAS, the Board of County Commissioners and Planning Commission held a public workshop on November 18, 1996 wherein they heard input from the public, KCM, Inc, (Consultant) and County staff; and

WHEREAS, on December 9, 1996 the Planning Commission held a public hearing wherein staff presented a status report and the public provided testimony and recommended to the Board of County Commissioners that they adopt the Skokomish River Comprehensive Flood Hazard Management Plan, Volumes I and II, along with the amended Executive Summary and corresponding revisions to the main body of the plan, as presented as Addendums 1 and 2 of the staff report dated December 9, 1996; and

WHEREAS, the Planning Commission also recommended that the Board of County Commissioners address three issues following the adoption of the CFHMP which included consideration to; (1) placing the diking reconnaissance study and levy analysis as a first priority in the list of unprioritized flood management alternatives recommended by the Planning Advisory Committee; (2) examining the accuracy and implications of the No-New-Footprint-Zones as set forth in the CFHMP and proposed Flood Damage Prevention Ordinance; (3) take into consideration the fact that the East Bourgault Road is a priority area for the acquisition of flood damaged properties, and that this area should be designated as a No-New-Footprint-Zone to prevent future construction; and

WHEREAS, on December 18, 1996 the Board of County Commissioners held a public hearing. They were given a staff report that presented a background on the development of the proposed CFHMP, informed that the Planning Commission recommended adoption of the CFHMP along with the creation of an ad-hoc committee to review three areas of concern;

WHEREAS, after receiving public testimony the Board elected to continue the hearing to December 30, 1996; and

WHEREAS, on December 30, 1996 the Board of County Commissioners received additional information from staff and the public and elected to adopt the April, 1996 draft of the Skokomish River Comprehensive Flood Hazard Management Plan which includes both Volume I and II per the following:

1. Include the amended Executive Summary (Addendum 1-Executive Summary) and corresponding revisions (Addendum 2-Changes To The Main Body Of The Plan Consistent With Changes In The Executive Summary) to the main body of the CFHMP.

2. Include the East Bourgault Road area in the no new footprint zone.

3. On Page ES-4, Issue 1, Bottom of page. Last Paragraph before bullet:

   RIVER BANK STABILIZATION RECOMMENDATIONS

   Add what is highlighted.

   This Plan promotes the use of bioengineered riverbank stabilization whenever possible. Emplacement of rock rip-rap is recommended in locations where no other solution is feasible and the potential for flood damage is great. **AS AN EXAMPLE**, bank protection using rock rip-rap is recommended in the following locations:

4. On Page 5-13, Chapter 5

   PERMIT PROCESS

   (INSERT BEFORE FIRST PARAGRAPH)

   No person shall be stopped from responding to any emergency per WAC 220.110.020 (7) and RCW 75.20.103.

5. On Page 6-74, Chapter 6, Issue 7, top of page, second bullet

   NEED FOR FLOODPLAIN DEVELOPMENT REGULATIONS

   Remove the word **RECONSTRUCTION.**

6. On Page 6-80, Chapter 6, Density Floodway, Top of Page, Third bullet

   Take out the third bullet and add: The sum total of all the structures footprint shall not exceed 6534 square feet in a five acre area or to FEMA standards in this adoption and is open for further review.

7. The boundary lines for Zone 2 will remain as they are for this adoption and are open for further review,

8. Delete Zone 1 from the no-new-footprint-zones for this adoption and is subject to being opened for further review.

9. Refer to Issue 7, on Page ES-8 and rewrite the third bullet to read: The minimum allowable space between structures parallel and perpendicular to flow is subject to the Mason County Comprehensive Plan and FEMA standards and further review is requested.

10. Add the following definition for **MAINTENANCE** - The work necessary to preserve or restore the natural condition or to restore man-made flood control facilities to their former condition using in-kind replacement materials or acceptable alternatives. This work is necessary due to anticipated or actual damage or destruction from flooding by action of erosion, stream flow, sheet runoff, or other damages by the sea or other bodies of water.

NOW, THEREFORE, BE IT RESOLVED THAT:

The Mason County Board of Commissioners hereby adopts the Mason County Skokomish River Comprehensive Flood Hazard Management Plan

which is not intended to provide a means to eliminate flooding but implementing recommendations within the plan to reduce flood hazards given the inevitability of flooding.

DATED this 30th day of ~~January~~ December, ~~1997~~ 1996. MJC MLF

ATTEST:

Rebecca J. Rogers

CLERK OF THE BOARD

APPROVED AS TO FORM:

Kelly, Deputy

PROSECUTING ATTORNEY

BOARD OF COUNTY COMMISSIONERS
MASON COUNTY, WASHINGTON

Mary Jo Cady

CHAIRPERSON, MARY JO CADY

M. L. Faughender

COMMISSIONER M.L. FAUGHENDER

Abstain

COMMISSIONER WILLIAM O. HUNTER

(valley)

ACKNOWLEDGMENTS

This document was prepared for the Mason County Department of Community Development by KCM, Inc. (KCM), under the direction of A.M. (Tony) Melone, Ph.D., P.E. Gary Cooper served as project manager for Mason County.

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EXECUTIVE SUMMARY

The Skokomish River Valley is an area of great natural beauty and rich agricultural land that has attracted people to live and work in the floodplain for hundreds of years. However, the Skokomish River floodplain is also an area of great natural hazards. Inundation of property, erosion of land, and threats to personal health and safety occur on a frequent basis in the Valley as a result of flooding from the Skokomish River.

Extreme events that appear to occur with increasing frequency have devastating effects. The largest flood event of record occurred recently, in December 1994. The Skokomish at Potlatch gauge operated by the USGS recorded a stage of 17.91 feet, 2.8 feet above the official flood stage at this location. While the exact discharge and related flood frequency are not known for this event, it is likely that the event was equal to or greater than the 100-year event. Damages from the flood were severe and widespread throughout the valley, including extensive damages to US 101.

The overall goal of this Comprehensive Flood Hazard Management Plan is to reduce hazards from frequent and infrequent events using actions that are appropriate to conditions in the Skokomish Valley. The plan was developed with the understanding that catastrophic flood events have occurred repeatedly in the past and will continue to occur. The recommended actions are not designed to prevent catastrophic floods, but to lessen the impact of floods on people and their property.

This plan integrates the following three previously published documents relating to flood hazard management planning for the Skokomish Valley:

- 1988 Skokomish River Comprehensive Flood Control Management Plan—Preliminary Draft Plan, prepared by the Washington State Department of Ecology (Ecology)

- 1993 Skokomish River Comprehensive Flood Hazard Management Plan—Volume II Draft, prepared by KCM, Inc.

- 1995 Skokomish River Comprehensive Flood Hazard Management Plan—Draft Chapters, prepared by KCM, Inc.

Two major resource development activities have been practiced in the upper subbasins of the Skokomish River watershed, dramatically altering environmental conditions in the upper and lower subbasins and affecting flooding in the Skokomish Valley. These activities—logging in the South Fork and diversion of the North Fork out of the watershed by the Cushman hydroelectric project—have contributed to unnatural filling of the river channel, resulting in rising elevation of the river bed, diminished channel capacity, progressively more frequent and severe flooding, accelerated risk of channel migration, and higher ground water levels. Additionally, some channelization features on the valley landscape, such as state bridges, county roads, and natural bank features, have contributed to observed aggradation upstream of these features. The high rate of channel aggradation has been identified as a root cause of progressively more severe Skokomish River flooding problems.

Extensive clearcut logging in the South Fork subbasin has occurred over several decades on federal forest and private lands. The result of this practice has been a drastic alteration of the natural hydrologic regime. Removal of forest vegetation in the South Fork causes increases in flood magnitudes and frequencies, and increases sediment input to the Skokomish River.

The North Fork subbasin has been changed by a different kind of human intervention. The Cushman Hydroelectric Project diverts about 90 percent of the natural North Fork flow, or 45 percent of the total mainstem flow, directly into Hood Canal. This alteration of the hydrologic regime has had both positive and negative impact on flooding in the lower valley.

Lake Cushman, created by a dam on the North Fork of the Skokomish River, stores floodwaters and significantly reduces peak discharges that would otherwise cause extensive downstream damages. The reduction in flow from the North Fork Skokomish River reduces sediment carrying capabilities of the mainstem and contributes to unnatural aggradation in the mainstem Skokomish. Although there is uncertainty regarding the exact amount the aggradation has increased, there is a general consensus that the rate has increased. The result is that sediment transported from the upper watershed is deposited at a faster rate in the mainstem, raising its bed and decreasing its capacity to convey floodwaters and sediment, thus increasing flooding in the Valley.

The effects of upper basin resource development activities on flooding in the lower valley are discussed in detail in this report. Valley land management activities, such as farming and diking, have also affected flooding, and are also discussed. Issues related to these and a wide range of other relevant flood hazard management topics were developed out of a review of past records, discussions with Valley residents, and meetings with a planning advisory committee established for the planning effort.

The Planning Advisory Committee established by the Mason County Board of Commissioners included representatives from Mason County departments of Public Works and Community Development, Washington Department of Ecology, Washington Department of Fish & Wildlife, Skokomish Indian Tribe, the Skokomish Flood Control Advisory Board and Valley residents. The goal of the Planning Advisory Committee is to reach consensus that resolves the complex outstanding flood control issues in the Skokomish River Basin—where consensus cannot be reached areas of agreement and disagreement will be identified. The merits of potential alternatives were debated at length during regularly scheduled planning advisory committee meetings, and decisions made by consensus. Consensus was reached on key goals and objectives and on actions appropriate to address several flood issues, including a basic method for regulating floodplain development consistent with FEMA regulations, policy for diking, and policy for reducing adverse effects of the Cushman Project.

The Planning Advisory Committee adopted a number of "Key Elements" to provide overall guidance for the Skokomish Valley Comprehensive Flood Hazard Management Plan. The Key Elements are presented in the Introduction section of the Plan.

ISSUES AND RECOMMENDATIONS

Ten major issues were identified during the planning effort and the recommended actions were proposed in this plan to address them.

Issue 1: Forest Practices in the South Fork Watershed

Forest practices in the South Fork Watershed have contributed to sedimentation in the lower mainstem, causing increased flooding. Recommendations to address this problem include restoration activities and changes in forest practices in the South Fork Watershed; and mainstem widening and side-channel clearing, gravel removal, and river bank stabilization in the lower watershed.

South Fork Watershed Recommendations

The U.S. Forest Service (USFS) owns roughly 50 percent of the Skokomish Watershed. This CFHMP fully supports recommendations presented in the USFS Watershed Analysis. They are as follows:

- Create riparian reserves along streams and rivers according to the maximum widths recommended in federal standards
- Continue implementation of sediment input reduction actions with project priority based on potential for site to deliver sediment to streams or sustain vegetative cover
- Evaluate road management objectives and maintenance strategies to address sediment reduction on high sediment roads
- Eliminate unstable sidecast areas and mass wasting hazards with a high risk of delivery to streams.
- Use strategies such as delayed thinning, smaller harvest units with longer periods between harvests, and reduction of road construction to promote hydrologic balance
- Continue successful watershed restoration projects such as road decommissioning and bioengineering of eroding slopes.

The other major landholder in the South Fork Skokomish Watershed whose actions have affected flooding in the Valley is the Simpson Timber Company. The following recommendations for actions on Simpson lands are based on their communications during development of this CFHMP.

- Simpson should complete a watershed analysis for lands it owns in the Skokomish Watershed. Historical and current volume estimates of mass erosion rates, sediment delivery to streams, and transport to the mainstem should be provided for use in a mainstem sediment balance.
- Simpson should make copies of its Road Maintenance, Rehabilitation, and Abandonment Plan available to all members of the PAC and Skokomish Valley residents and provide periodic status presentations.

Lower Watershed Recommendations

A principal goal of this CFHMP is to restore and maintain the water and sediment carrying capabilities of the Skokomish River system. This will require addressing the root problems of channel aggradation by 1] reducing or eliminating unnatural sediment contributions from South Fork forest lands using methods identified in South Fork Watershed Recommendations, above; and 2] reducing or eliminating the Cushman Project's contribution to the river's reduced sediment carrying capabilities with managed flushing flow releases for the mainstem [See Issue 2, Cushman Project].

Lower Watershed Gravel Removal Recommendations

In addition to direct mitigation measures that address the root causes of increased mainstem channel aggradation, several complementary actions are recommended to mitigate sediment-related flood damages, further quantify sedimentation processes, and investigate innovative approaches to sediment management.

Gravel removal proposals should be coordinated with overall plans for restoring and maintaining channel capacity. However, it is not the intent of the Plan to make gravel removal projects contingent upon prior implementation of managed flows designed to increase the mainstem's sediment transport capabilities.

This CFHMP supports recommendations to the Federal Energy Regulatory Commission by the Skokomish Tribe and state and federal resource agencies that managed flow releases from the Cushman Project be required that will substantially restore river and estuary fish habitat conditions and the mainstem's natural sediment carrying capabilities. Managed flow releases would be designed to effectively treat unnaturally high rates of channel aggradation in the mainstem Skokomish River and restore to the maximum extent practicable the natural sediment carrying capabilities of the mainstem. Managed flow releases from the Cushman Project—not to exceed bankfull levels on the mainstem—should be determined by a program of testing and monitoring, which would also identify the extent to which mechanical removal of accumulated bedload, including gravel bar removal and instream dredging, may be necessary to restore mainstem channel capacity. Any instream dredging project should be supported by good science, shown to be beneficial for fish life and habitat, and be supported by a consensus of local, tribal, state and federal regulatory and concerned agencies and community.

Based on existing information, Mason County and the Skokomish Tribe believe that mechanical removal of accumulated bedload will be required—in combination with managed flushing flows—to fully and expeditiously restore the mainstem's capabilities to carry water and sediment.

Monitoring

The recommended sediment monitoring program consist of two components:

- Monitoring sediment movement at key locations, including locations where historical data is available

- Surveying channel cross-sections annually and taking aerial photos every 2-3 years to determine changes in response to sediment movement.

Gravel Bar Scalping Projects to Increase Channel Capacity

Pre-engineering design analysis is recommended for a program of gravel bar scalping to increase channel capacity in river reaches where insufficient capacity has been documented. This analysis would identify priority locations, estimate expected benefits, costs, and environmental impacts, and identify relationship with overall plans for channel restoration. The average channel capacity between US 101 and the confluence of the North and South Fork Skokomish Rivers is approximately 8,000 cfs. Removal of gravel through gravel bar scalping at recommended locations would increase channel capacity by an average of approximately 3,700 cfs.

Feasibility Analysis of Sediment Exclusion and Ejection

The feasibility of sediment exclusion and ejection alternatives should be determined through a detailed feasibility analysis. The feasibility analysis should include development of conceptual designs for the facility, collection of geotechnical information from potential sites, estimates of costs of implementation and operation, benefits for flooding, and environmental impacts. If the feasibility analysis is favorable, design and implementation of a pilot project of sediment removal and associated monitoring should be accomplished. The pre-engineering design analysis and any pilot project should be coordinated with overall plans for channel restoration.

Mainstem Widening and Side-Channel Clearing Recommendations

The purpose of this project would be to reduce mainstem flooding and provide additional fish habitat. Detailed engineering, cost, flood benefit, and environmental investigations are required to assess and develop this proposal.

The following recommendations were developed by the consultant based on HEC-2 modeling results. The modeling results indicated that conveyance capacities could be increased by approximately 3,500 cfs in the reach of the river between US 101 and a point approximately two miles upstream of US 101.

- Selectively clear trees and brush in the North Overflow from the US 101 bridge to a distance approximately 1,500 feet upstream

- Double the width of the mainstem channel of the river between US 101 and a location approximately 1,500 feet upstream of US 101

- Remove a forested gravel bar on the north side of the channel approximately two miles upstream of US 101

- Widen by 100 feet the downstream end of a meander bend located approximately 1.5 miles upstream of US 101.

Implementation of recommended actions relating to mainstem widening and side channel restoration will require the collaboration with the Skokomish Tribe, and integration with

overall planning for channel restoration and improvement of natural sediment transport through managed restoration of flows. In addition, as is the case with any of the actions that may use, divert, obstruct, or change the natural flow or bed of the river, the Washington State Department of Fish and Wildlife (WDFW) would be consulted prior to design and construction.

River Bank Stabilization Recommendations

River bank stabilization, if carefully designed, can mitigate the impact of erosion caused by flood flows. Improperly designed bank stabilization projects can cause adverse effects to fisheries, promote erosion in the bank targeted for protection or other nearby riverbanks, and increase flood damage.

This plan promotes the use of bioengineered riverbank stabilization whenever possible. Emplacement of rock rip-rap is recommended in locations where no other solution is feasible and the potential for flood damage is great. As an example, bank protection using rock rip-rap is recommended in the following locations:

- Five Mile Corner: The force of the river in this area is directed at the southern bank. Four homes located within 200 feet of the southern bank are threatened by a potential channel avulsion.

- The Dips: Water flows over the road in this location during flood events and is conveyed through the floodplain towards Swift Creek, Eels Road and the Shelton Trout Hatchery.

- Skokomish Community Church: The dike in the County road right of way at the sharp bend in the river near the church was not built to current engineering standards and is in danger of failing. An avulsion at this location could damage or destroy the church, several homes and private property, and the Skokomish Valley Road. Stabilization of the river bank at this location will be planned in conjunction with evaluation of the existing dike in the County road right of way consistent with adopted diking policy.

Issue 2: Diversion of North Fork Flow by the Cushman Hydroelectric Project

Diversion of flow by the Cushman Hydroelectric Project has changed the hydrologic regime of the river, reducing its sediment carrying capacity and causing increased flooding. Modifications to the operation of the Cushman Project are being considered as part of procedures being conducted by FERC to evaluate Tacoma Public Utilities' application for major license. These modifications involve changing the amount of water released from Lake Cushman to the North Fork.

The Skokomish Tribe and Federal and State resource agencies have recommended to the Federal Energy Regulatory Commission that North Fork streamflow be restored in a way that substantially restores river and estuary fish habitat conditions and the mainstem's sediment carrying capabilities. Sediment transport capabilities of the mainstem would be optimized through managed flow releases from the Cushman Project, not to exceed bankfull levels on the mainstem. The Planning Advisory Committee endorsed this strategy as essential to reduce or eliminate Cushman Project contributions to future channel aggradation, consistent with

maintaining flood storage provided by the Cushman Project and high summer recreational pool levels in Cushman Reservoir.

There is uncertainty about the effect that managed flushing flow releases to the North Fork will have on flushing accumulated bedload from the mainstem river. Therefore, this CFHMP supports pilot testing of enhanced sediment transport through controlled releases from the Cushman Project to determine optimum flushing flows and the extent that mechanical removal of accumulated bedload will be necessary to restore channel capacity and the related objective of lowering groundwater levels. Mason County and the Skokomish Tribe believe that mechanical removal of accumulated bedload will be required—in combination with managed flushing flows—to fully restore mainstem channel capacity.

The project should continue to provide flood hazard management benefits by limiting releases so that flows in the mainstem near US 101 do not exceed bankfull levels, presently about 5,000 cfs. Mitigation for flood damages resulting from Cushman Project-related channel aggradation in the Lower Mainstem should be provided by Tacoma Public Utilities in the form of funding for flood hazard management projects recommended in this CFHMP.

Issue 3: Increase in Flood Levels Caused by US 101

US 101 causes localized increases in flood levels. During extreme events most of the flow is not conveyed through the main bridge opening due to the topography in the vicinity of the highway. Under current conditions, only 36 percent of the 100-year flood flow is contained within the main channel; approximately the same amount flows towards the Purdy Creek bridge.

Modification of the US 101 embankment and bridges will provide local reductions in flood depths and associated damages. A pre-engineering design should be completed—in coordination with mainstem channel restoration proposals—to evaluate alternative methods and their costs and flood benefits for the following highway 101 modifications:

- Increase the capacity of the north overflow by selective removal of woody debris and brush near the bridge opening and in the slough
- Raise the roadway near Purdy Creek to an elevation of 35 feet and increase the area of the opening under Purdy Creek by a factor of three
- Increase the area of the main channel bridge opening by a factor of 1.5.

These recommendations are contingent on the following:

- The roadway adjacent to the Purdy Creek Bridge should not be raised without enlarging the bridge opening
- Any enlarged bridge opening at Purdy Creek should have at least the same hydraulic capacity as the combined flows at the existing Purdy Creek bridge and the adjacent US 101 overflow

- Any enlarged bridge opening at Purdy Creek should not be made so large that it will result in a significant redistribution of flows through openings at US 101

- The area within 1,000 to 2,000 feet of the Purdy Creek Bridge should be kept as open as possible to allow for conveyance of floodwaters during extreme events

- Modification of openings in the US 101 embankment should be implemented only after careful consideration and mitigation of potential impact to downstream property.

Issue 4: Increased Flood Levels Caused by SR 106

SR 106 causes localized increases in flood levels during extreme events. Development and analysis of alternatives to mitigate potential flood effects of SR 106 were not completed for this CFHMP since it was beyond the scope of the plan. A pre-engineering design should be completed—in coordination with mainstem channel restoration proposals—to evaluate the costs, flood benefits and environmental effects of the following two alternatives for increasing the effective area through which floodwaters can be conveyed:

- Remove the entire embankment east of the intersection of Skokomish River Road and SR 106 in the area of deepest flooding. Replace the embankment with an elevated causeway.

- Enlarge the bridge opening.

These alternatives should be analyzed using the calibrated HEC-2 model prepared for-this CFHMP.

Issue 5: Conveyance of Floodwaters Back into the River Following Floods

Floodwaters are not adequately conveyed back into the river following flood events. The following recommendations were developed to enhance conveyance of floodwaters from the floodplain to the river during and following flood events. These recommendations are complemented by hydraulic improvements recommended for Issue 3 and regulatory approaches recommended for Issue 7.

- Overbank Vegetation Removal: Overbank vegetation should be selectively removed from Weaver and Purdy Creeks between US 101 and a location approximately 300 feet upstream. The Washington State Department of Transportation (WSDOT) should complete this maintenance activity at least annually. The WDFW should be consulted regarding an ongoing maintenance program at this location to streamline permitting requirements.

- Debris Blockage Removal: Debris blockages to be targeted for removal were identified at eight locations as part of the 1993 Draft CFHMP. Debris blockages that remain at these locations should be removed. The County should implement an ongoing maintenance program in coordination with the WDFW and the Skokomish Tribe to remove blockages that recur at these locations and

blockages that develop at other locations. The program should include annual inspections and record keeping elements.

- Drainage Improvements: The County should implement a program for local property owners to develop and implement on-site drainage projects. These Projects would benefit the public since floodwaters would be conveyed back to the river more rapidly during flood events, reducing the length of time roadways and other public facilities are inundated. Funding should be developed on a cost share basis between the County and the local property owner. FCAAP maintenance grants should be considered as a potential funding source.

It is critical that the nature and extent of expected reductions in flood damages and the impact on fisheries and riparian areas be identified and evaluated prior to implementation of any recommendations described above.

Issue 6: Repetitive Damages to Structures in High Hazard Areas

Structures in the valley located in the highest hazard areas receive repetitive damages, resulting in a cycle of damages, disbursement of state and federal monies, and repairs. This cycle is costly to the property owner and the public.

A five-step hazard analysis was completed to recommend habitable structures located in the Skokomish Valley for acquisition. The steps included mapping of flood inundation and flood hazards, and compiling of databases of property ownership and habitable structures.

Following recommendations for acquisition, public comment was solicited. Input from the Skokomish Tribe was also requested and obtained.

A total of 82 structures are recommended for acquisition of which 38 are located on tribal land. The 38 tribal-owned structures were recommended by the Tribe for acquisition. The County, in coordination with Ecology, should pursue potential sources of funding for acquisition of all structures recommended for acquisition. Descriptions of potential sources of funding are included in Chapters 5 and 7 of the CFHMP.

The results of the flood hazard analysis were also used to develop a no-new-footprint zone map. No-new-footprint zones were based on identification of the highest hazard areas in the valley as depicted on the hazard maps.

The objective of the establishment of no-new-footprint zones is to provide a regulatory mechanism for preventing new development in the highest hazard areas in the Valley. Redevelopment would be allowed to occur only if the area of the new footprint is equal to or less than the old footprint of the structure. The map of no-new-footprint zones and regulatory text to achieve these objectives should be incorporated into the new flood damage prevention ordinance recommended in Issue 7.

Issue 7: Potential for Flood Damages to Future New Development

Future construction of homes and businesses in the Skokomish Valley will result in additional hazards to people and property. Floodplain development regulations are needed to both limit development and provide guidance on new development to minimize future flood hazards.

The County should adopt a flood damage prevention ordinance and Flood Insurance Rate Map (FIRM) based on the density floodway approach, where no distinction is made between floodway and floodway fringe. The effect of development on floodplain hydraulics is controlled by limiting the allowable percent development on each parcel throughout the floodplain. Development criteria produced during a density floodway analysis are integrated into the flood damage prevention ordinance to limit future increases in water surface elevations resulting from development.

A draft flood damage prevention ordinance was prepared based on the results of the density floodway analysis and is included in Appendix DD. The following development criteria are included in the ordinance:

- The maximum allowable percentage development is 3 percent
- The maximum allowable width of a structure parallel and perpendicular to flow is 80 feet
- The minimum allowable space between structures parallel and perpendicular to flow is subject to the Mason County Comprehensive Plan and FEMA standards and further review is requested
- The maximum blockage that should be allowed is 17 percent.

The draft ordinance also incorporates provisions to ensure that no new construction occurs in high hazard areas and redevelopment occurs only if the area of the new footprint is equal to or less than the old footprint of the structure (see Issue 6). In order to adopt the ordinance, the County process for development and adoption of regulations should be followed. The County should also initiate a process of map revision with FEMA.

Issue 8: Engineering Standards and Regulatory Compliance for Levees

The current system of riverbank levees are discontinuous and the construction methods used to build them were not up to current engineering standards for levee construction. In addition, they do not meet FEMA regulations. Any dikes that are constructed should meet basic structural standards and FEMA regulations, not cause increased flood hazards, and be set back from the natural stream channel and stream bank.

On October 24, 1995 the Planning Advisory Committee adopted a policy on dikes. Agreement was reached that: "Diking is not a preferred alternative for addressing flooding in the Valley, but there are instances where dikes can provide legitimate flood protection." The Planning Advisory Committee recommended as a priority completion of a reconnaissance analysis of existing dikes to "to develop recommendations for removal, abandonment, or approval for maintenance and upgrading" to meet its approved minimum standards for dike construction,

alteration and maintenance. Under the PAC's recommended diking policy, "Applications for construction, alteration and maintenance of dikes shall be considered on a case-by-case basis." The full policy is presented in Chapter 6 and its adoption is recommended in this report.

The CFHMP includes design guidelines for construction of a low-level berm and a tabulation of maximum berm heights allowable under FEMA regulations. This information is provided so that it can be used for any future planning concerning dikes.

Prior to modification of the existing levee system, a detailed reconnaissance report on existing dikes is recommended as proposed by the Planning Advisory Committee. The report would serve the following purposes:

- Prioritizing future projects
- Establishing a realistic budget for bringing the dikes into compliance with the existing policy
- Making future permitting decisions on private dike repair requests
- Determining the degree to which each dike provides private versus public benefits.

Issue 9: Flood Protection for Individual Property Owners

Individual property owners should have flood protection through floodproofing. The Army Corps of Engineers is currently completing a Flood Audit for the Skokomish Valley. Information will be provided to residents on specific actions that they can take prior to, during, and after a flood. Detailed recommendations will be provided for appropriate floodproofing methods for each structure. Recommendations will be based on costs and benefits of actions to protect structures from site-specific hazards. The Flood Audit should be completed as soon as possible, and not later than the start of the 1996-1997 flood season.

Individual property owners should review recommendations for their property contained in the Flood Audit. In the interim, common floodproofing approaches presented in this report should be considered on an individual basis so that residents can achieve personally acceptable levels of protection as soon as possible.

The County should pursue funding through the National Mitigation Fund and other programs to assist local property owners in financing floodproofing projects. Prior to pursuing funding, the County should use information presented in the Flood Audit and the flood hazard analysis completed in this CFHMP to develop a prioritized program of floodproofing projects.

Issue 10: Flood Warning and Emergency Response Program

The current flood warning and emergency response program needs enhancement. Residents need to know when a flood is occurring or is likely to occur and its projected magnitude and duration in order to take appropriate measures to protect their property and to evacuate to safe locations. Recommendations for this issue relate to actions that will enhance flood warning and

emergency response during dam releases and flood warning and emergency response during dam failure.

Flood Warning and Emergency Response during Dam Releases

Make it easier for Valley residents and the Tribe to obtain information about flood conditions directly. Obtain access for the Skokomish Tribe and the Skokomish River Flood Control Zone District to U.S. Geological Survey (USGS) gauge data. Designate an emergency control center during flood conditions and a contact person who will be responsible for contacting Tacoma Light Division's Energy Control Center. Establish a computer link to obtain USGS flow data.

Provide information directly to Valley residents about releases. This can be facilitated by designating a person from the Valley for the Tacoma Light Division to contact in the event of a release. A procedure should also be established to notify the rest of the residents in the Valley.

Flood Warning and Emergency Response During Dam Failure

Establish a more direct way to warn residents. Sirens should be installed in the Valley to warn residents of a dam failure. Local television and radio stations, especially those included in the emergency broadcast system, should be notified immediately.

IMPLEMENTATION CONSIDERATIONS

Funding will be required to implement the recommended actions. Potential funding sources include state and federal grant and loan programs and local revenues generated through the use of special purpose districts. This plan recommends that parties involved in upper watershed resource development activities that have had negative effects on flooding in the valley should contribute to implementation of the CFHMP recommendations. These parties include the U.S. Forest Service, Simpson Timber, and Tacoma Public Utilities.

Comprehensive Flood Hazard Management Planning is an ongoing process. This plan should be periodically updated to reflect the changing conditions in the valley and the new issues and potential actions that may result. The provisions of this plan should be incorporated into any other related planning efforts, such as the watershed planning effort being led by the Skokomish Tribe, to ensure that the flood hazard management objectives contained in this CFHMP are achieved.

RESPONSE TO COMMENTS ON DRAFT PLAN

This final version of the Skokomish River Comprehensive Flood Hazard Management Plan reflects changes made during the comment period and adoption process. Comments on the draft CFHMP and materials related to the adoption process are included as Appendices OO, PP, QQ, and RR.

CHAPTER 1.
INTRODUCTION

Residents of the Skokomish River Valley, including members of the Skokomish Tribe, have been affected by human activities in the watershed during the past decades. These activities have been conducted by private industry, a public utility, state and federal agencies, and owners of residential property. Valley residents, located at the most downstream segment of the watershed, are affected by the cumulative effects of activities throughout the watershed.

Flooding has always occurred in the Skokomish Valley. However, available information suggests that flooding occurs more frequently now than in the past. Watershed problems have become so severe that the conservation group American Rivers has identified the Skokomish River as one of the 15 most threatened rivers in the United States.

Flooding, and the consequent danger to life and property, is a fundamental fact of life in the Skokomish Valley. This Comprehensive Flood Hazard Management Plan (CFHMP) is not intended to provide a means to eliminate flooding but implementating recommendations within the plan will reduce flood hazards given the inevitability of flooding.

The approach adopted for the CFHMP is to maintain a balance among the following:

- Mitigation of the adverse impact on public health and property in the valley caused by activities undertaken throughout the watershed
- Protection and enhancement of the environment
- Compliance with county, state, and federal regulatory programs affecting flood hazard management activities.

TERMINOLOGY

The terms *flood control management*, *floodplain management*, *stormwater management*, and *flood hazard management* are commonly used to describe ways to minimize or prevent flood damages:

- *Flood control management* usually entails structural techniques for separating people and property from damaging floodwaters. Non-structural techniques, such as land use regulations and growth management, have typically been excluded from flood control management.
- *Floodplain management* involves resource protection, environmental enhancement, flood damage protection, and land use regulations within the floodplain.
- *Stormwater management* focuses on the quality, quantity, and controlled conveyance of surface runoff from precipitation events.
- *Flood hazard management* encompasses flood control management and floodplain management techniques, including structural and non-structural approaches extending from the river to the floodplain. Flood hazard management in this report also includes stormwater management, since many

of the issues associated with flooding from river or tidal waters also pertain to flooding due to stormwater runoff.

A final term with bearing on the potential for flooding and associated damages is *watershed management*. Watershed management is an umbrella term under which many land and water management activities take place within a watershed to achieve a variety of objectives. These objectives may include water supply enhancement, fish and wildlife habitat improvement, fire suppression, and flood hazard management.

Flood hazard management, to be successful, must take into account human and environmental interaction with the river. Like most rivers, the Skokomish is a dynamic system where flooding is natural and normal. However, human intervention in river systems can exacerbate the extent of flooding, its effects on human health and property, and its effects on the environment. Flood events may have positive or negative effects on the environment, such as building or destroying habitat, depending on the characteristics of the event. Any activity or use of a river or its adjacent lands may change the characteristics of flood events. These changes must be understood before proceeding with any flood hazard management action.

COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

This CFHMP has evolved based on guidelines and requirements contained in the following:

- Detailed grant agreements between Mason County and the Washington State Department of Ecology; and contractual agreements between Mason County and KCM, Inc., based on the grant agreements
- Washington State regulations for Comprehensive Flood Hazard Management Planning
- A list of "Key Elements of the Skokomish Valley Comprehensive Flood Hazard Management Plan" adopted by the Skokomish Valley Comprehensive Flood Hazard Management Plan Planning Advisory Committee (Advisory Committee).

Authority and Scope

Funding for this Final Draft Skokomish River Comprehensive Flood Hazard Management Plan was authorized by Mason County on January 23, 1996. Work towards project completion has also been funded under two previous contracts with Mason County, dated November 17, 1992, and August 30, 1994. Funding for all previous and current work was provided under agreements with the Washington State Department of Ecology (Ecology), which contributed 75 percent of the project costs through the Flood Control Assistance Account Program (FCAAP), and Mason County, which contributed the remaining 25 percent from County funds. This CFHMP, in its final form when approved by the County and Ecology, fulfills the requirements of these agreements.

The format of this CFHMP, and of the alternatives and recommendations for flood hazard management presented within, is in accordance with the Revised Code of Washington (RCW) Chapter 86.26: *State Participation in Flood Control Maintenance* and Washington Administrative Code (WAC) Chapter 173-145: *Administration of the Flood Control Assistance Account Program.*

Flood Control Assistance Account Program

The Washington State program to assist local jurisdictions with comprehensive planning and flood control maintenance is described in *State Participation in Flood Control Maintenance* (RCW 86.26), originally enacted in 1951 and amended in 1984. Funds for flood control maintenance projects and for preparation of CFHMPs are available through the FCAAP. Administrative and procedural information relating to FCAAP and RCW 86.26 can be found in *Administration of the Flood Control Assistance Account Program* (WAC 173-145). Additional information on state statutes addressing flood hazard management is presented in Chapter 5.

Funding

Distribution of FCAAP grant money depends on the amount appropriated by the state legislature each biennium, and is based on the eligibility of the applicant and the proposed project. Proposals are reviewed by several state agencies to ensure that appropriate resource issues and regulations are adequately addressed. Legislative appropriations for FCAAP, made each biennium, have varied from no funding (from 1975 through 1985) to the maximum allocation possible under State statute, $4 million. The current biennium's appropriation is $2.7 million. Restrictions include the following:

- Non-emergency project grants are limited to 50 percent of the total cost
- The non-emergency FCAAP contribution is limited to $500,000 per county
- Emergency funds of up to $150,000 per county per biennium are available on a first come/first served basis; the State will fund up to 80 percent of the cost of emergency projects
- Unused emergency funds can be disbursed on a discretionary basis by Ecology
- The State can fund 75 percent of the cost for comprehensive flood hazard management plans.

Requirements for CFHMPs

To obtain funds for flood control maintenance through FCAAP, jurisdictions must prepare a CFHMP that, as discussed in RCW 86.26.105, accomplishes the following:

- Identifies the river's meander belt or floodway
- Establishes the need for flood control work
- Considers alternatives to in-stream flood control work
- Identifies and considers the potential impact of in-stream flood control work on the state's in-stream resources.

The CFHMP must also establish and rank appropriate structural and non-structural measures to reduce flood damages. The study area may include the entire watershed or, at a minimum, the 100-year-frequency floodplain within a reach of the watershed. The reach must be of sufficient length that a comprehensive evaluation can be made of its flood problems. The completed CFHMP provides the technical foundation for future structural and non-structural flood hazard management measures.

State law requires that a CFHMP describe the area where proposed projects are located, and the types and locations of existing flood problems. A complete description of the information a CFHMP must include is contained in WAC 173-145-040. Among the required information is certification from the Washington Department of Community, Trade and Economic Development (CTED) that the local emergency management organization is administering an acceptable comprehensive emergency operations plan. That certification is included as Appendix A of this report. The law allows up to three years for local authorities to complete and adopt a CFHMP. Applications for project funding under the FCAAP program require the county engineer to certify whether a CFHMP plan has been completed and adopted or is in preparation. Ecology must approve the final CFHMP, and the municipality must adopt the plan subsequent to approval.

Applicant Eligibility

Counties, cities, and other local municipal corporations with flood control responsibilities, such as flood control districts or diking districts, are eligible to receive state funding for flood control maintenance projects. Eligible municipal corporations must file their flood control budget with Ecology by February 15 each year.

To receive funding for flood control maintenance projects, the county, city, or town having planning jurisdiction over the project area must have its floodplain management activities approved by Ecology; the requirements include the following:

- Participation in the National Flood Insurance Program (NFIP)
- Certification of the local emergency response plan by the State Department of Emergency Management (DEM)
- Restriction to flood-compatible land uses within a river's meander belt or floodway.

Adoption of a Shoreline Master Program (SMP) may also be required.

Maintenance Project Eligibility

Evaluation of proposed FCAAP projects is based on cost-benefit relationships, local priorities, intensity of local flood hazard management problems, and consideration of information in the CFHMP. Maintenance projects must be based on a comprehensive approach to flood hazard management planning and must meet specific guidelines with respect to project goals. Typical structural measures funded through FCAAP include installation of riprap on eroding stream banks, repair of riprap embankments, and the construction and maintenance of levees.

The legislation describes in general terms the type of maintenance work eligible for funding. Eligible work includes "maintaining and restoring the normal and reasonably stable river and stream channel alignment and capacity" and "restoring, maintaining, and repairing natural conditions, works and structures." State participation can also include "restoration and maintenance of natural conditions, works, or structures for the protection of lands and other property from inundation or other damage by the sea or other bodies of water" (RCW 86.26.090).

Funding for the enhancement of flood control facilities was authorized by Engrossed Senate Substitute Bill (ESSB) 5411, enacted in July 1991. This expands FCAAP project eligibility to include purchase of flood-prone properties or land to be used for flood storage, but only if these measures were identified in the applicable CFHMP (Ecology 1991).

Permits such as the Hydraulic Project Approval (HPA), Shoreline Substantial Development, and Conditional Use must be obtained before the project is funded by Ecology. All project plans and designs must be consistent with applicable SMPs and CFHMPs, and the projects must benefit the public, as opposed to strictly private interests.

Emergency Projects

A portion of the available FCAAP funding is reserved by law for emergency use. Projects considered emergencies are those that must be done immediately to protect life and property from "unusual, unforeseeable, and emergent flood conditions" (WAC 173-145-100). Release of emergency funds is contingent upon an emergency declaration by the appropriate authority. Depending on the emergency measure, a shoreline permit or HPA may be required.

Consultation with Other Agencies

A variety of state and federal agencies are involved in key river issues, such as fisheries resources, wildlife habitat, and public use. The presence of fisheries resources, primarily salmon and steelhead, is a key consideration in performing any flood hazard management activities in and around the waters of the State of Washington. The potential loss of fish habitat resulting from construction in and beside rivers has been a major concern for fisheries agencies, sports fishermen, and Native American groups.

To ensure that fisheries resources are maintained, the Washington State Department of Fish and Wildlife (WDFW) has review authority for most phases of the FCAAP. Ecology is required to consult WDFW before approving any CFHMPs. Applicants for FCAAP project funds must review their proposals with WDFW, the Washington State Department of Natural Resources (DNR), and the tribes with jurisdiction.

Construction work to be performed in or adjacent to navigable waters of the United States, including wetlands, must be approved by the U.S. Army Corps of Engineers (COE). The COE permit process ensures that all federal, state, and local regulatory agencies with jurisdiction over the project are properly notified and approve the project. The COE will not approve a project that has been rejected by another permitting agency.

Advisory Committee

A planning advisory committee for the Skokomish Comprehensive Flood Hazard Management Plan was established on April 14, 1992, by the Board of Mason County Commissioners. The committee members were selected to include representatives from the Mason County Department of Community Development, Washington Department of Fish and Wildlife, Skokomish Indian Tribe, the Skokomish Flood Control Board and Valley residents. Table 1-1 identifies the original and current advisory committee members

TABLE 1-1.
PLANNING ADVISORY COMMITTEE FOR THE SKOKOMISH RIVER
COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Name	Affiliation/Representation	Original (1992) Member?	Current (1996) Member?
Gary Cooper	Mason County Department of Community Development	no	yes
Jim Fraser	WDFW	yes	yes
Chuck Gale	Ecology	yes	no
Jerry Hauth	Mason County Public Works Department	no	yes
John Hawk	Skokomish Indian Nation resident or local resident with key interest	yes	no
Jeff Heinis	Citizen at Large	no	yes
Bill Hunter Jr.	Skokomish Flood Control Advisory Board - Middle Skokomish Valley	yes	yes
Wes Johnson	Skokomish Flood Control Advisory Board - Upper Skokomish Valley	yes	yes
Victor Martino	Skokomish Indian Nation	no	yes
Margie Schirato	Skokomish Indian Nation	yes	no
Dan Sokol	Ecology	no	yes
Evan Tozier	Skokomish Flood Control Advisory Board - Lower Skokomish Valley	yes	yes
Marley Young	Mason County Public Works Department	yes	no

A set of ground rules was established during formation of the advisory committee, a copy of which is included with this report as Appendix B. Characteristics and responsibilities of the advisory committee are described both in the declaration by the Board of Commissioners establishing the committee and within the ground rules as follows:

- Provide information on important issues in the basin regarding each member's respective interests
- Provide direction to the consulting team
- Build a consensus that balances competing objectives
- Comment on recommendations for flood hazard management included in the CFHMP.

The goal of the Planning Advisory Committee is to reach consensus that resolves the complex outstanding flood control issues in the Skokomish River Basin—where consensus cannot be reached areas of agreement and disagreement will be identified. The merits of potential alternatives were debated at length during regularly scheduled planning advisory comittee

meetings, and decisions made by consensus. Consensus was reached on key goals and objectives and on actions appropriate to address several flood issues.

Two policy statements have been published by the Advisory Committee. The first, "Key Elements of the Skokomish Valley Comprehensive Flood Hazard Management Plan," was adopted by the Planning Committee on May 18, 1995. The second, "Final Policy Statement on Dikes," was not adopted by the Advisory Committee. Its contents are discussed in Chapter 6.

The Key Elements to be included in the CFHMP either as objectives, issues, or actions, are as follows:

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Promote programs and strategies that are, to the greatest extent possible, consistent with the Tribe's goal of restoring the Skokomish River watershed through its watershed plan (objective).
- Incorporate existing information from other plans to provide direction in completing a plan for the Skokomish Valley, including the Skokomish Tribes Watershed Restoration Plan (when completed), the watershed plan of the Hood Canal Ranger District (when completed), Ecology's 1988 Draft, Skokomish River Comprehensive Flood Hazard Management Plan, and other documents that may prove relevant (objective).
- Remain eligible for all the benefits and assistance available through the Federal Emergency Management Agency (FEMA) by adopting a floodplain map and Comprehensive Plan that meet FEMA's requirements for flood hazard management (objective).
- Remain eligible for flood control for flood control assistance grants (objective) by meeting the minimum requirements for approval by Ecology of a Comprehensive Flood Plan.
- Address the issue of logging practices and the accumulation of bedload in the Skokomish River, and recommend a process for investigating those practices in an effort to reduce rates of bedload deposition (issue).
- Address the impact that diversion of North Fork flows out of the basin has had on the bedload transport capacity of the mainstem Skokomish River (issue).
- Promote and seek funding for gravel removal strategies to improve the hydraulic performance of the River (action).
- Identify areas in the Valley where land buyouts, land swaps, or relocation should be encouraged (action).
- Provide information about and promote floodproofing (action).

- Recommend and seek funding for emergency warning and evacuation equipment and procedures in conjunction with existing efforts by the local fire district and the Mason County Department of Emergency Services (action).
- Identify and recommend strategies to improve drainage throughout the Valley (action).
- Incorporate, to the greatest extent possible, the comments of citizens and agencies who have taken the time to read and evaluate earlier drafts of the CFHMP and to provide information to improve it (action).
- Recognize that the CFHMP is a "living document," and establish a timeline for updating it on a regular basis to incorporate new information (action).
- Identify areas that cannot be adequately addressed in the current Plan due to funding and time constraints, and recommend that these areas be phased into the Plan as practical (action).
- Identify areas where bank stabilization is needed for flood hazard management, and seek funding for bank stabilization efforts (action).
- Accompany each recommended flood control option with an estimate of costs and a timeline for implementation (action).
- Recommend that all flood control options implemented be monitored for results and that these results be documented (action).

PREVIOUS AND OTHER CURRENT STUDIES

Several other documents have been prepared and distributed previously or are planned for completion in the near future. Previously prepared documents that are relevant to this plan are listed in Table 1-2.

Previous Studies

Three prior investigations of flooding and potential flood control measures have been carried out on the Skokomish River: in the early 1940s by the COE (Dunn 1942), in the late 1950s and early 1960s by the U.S. Soil Conservation Service (SCS) (Cowley 1958; SCS file correspondence), and in the late 1960s as a part of the Puget Sound and Adjacent Waters (PSAW) Study carried out by the Pacific Northwest River Basins Commission (Flood Control Technical Committee 1970).

These investigations all use the basic benefit-cost analysis premise that the average annual equivalent benefits from a project must exceed the average annual equivalent costs of the project. That is, the benefits divided by the costs must exceed 1.0 for a project to be viable.

Apparently, none of these studies addressed the secondary costs of implementation, such as the damage to the anadromous fishery as a result of instream or streamside construction.

U.S. Army Corps of Engineers, 1942

In response to chronic and catastrophic flooding of the Skokomish Valley agricultural lands during the 1920s and 1930s, the COE initiated a study, reported to Congress in 1942.

TABLE 1-2.
PREVIOUS AND CURRENT STUDIES RELEVANT TO THE SKOKOMISH RIVER CFHMP

Document Name	Author	Date
Skokomish River Comprehensive Flood Control Management Plan - Preliminary Draft Plan	Ecology	March, 1988
Skokomish River Comprehensive Flood Hazard Management Plan, Volume II, Draft	KCM, Inc.	June, 1993
South Fork Skokomish Watershed Analysis	Watershed Analysis Team (led by USFS)	June, 1995
Draft Environmental Impact Statement	FERC	November, 1995
Flood Insurance Study	FEMA	May, 1988
Skokomish River Comprehensive Flood Hazard Management Plan, Draft Chapters	KCM, Inc.	June, 1995
Preliminary Evaluation of Effects of Flood Levels from the Existing Levee	Klohn Leonoff	May, 1989
Summary of Skokomish River Flood Plain Modeling for Natural (No Levee) Conditions	Klohn Leonoff	September, 1990
Report and Survey of Skokomish River, Mason County, Washington (presented to the House of Representatives, 76th Congress, 1st Session)	COE	March, 1942
Report of field examination Skokomish River Watershed, Mason County, Washington	SCS	1958
Comprehensive study of water and related land resources, Puget Sound and adjacent waters: Appendix XII, Flood Control.	Pacific Northwest River Basins Commission	1970

Annual flood damages, not including land erosion, had averaged about $13,400 in the first 16 years after the Cushman Dam was constructed in 1926. From 1931 to 1942, approximately 37 acres of farmland at several locations along the south bank of the channel eroded, a rate of about 3.4 acres a year, largely of developed farmland. The total annual combined cost, from flood damage and lost land, was $14,000 per year.

Prior to World War II, the agricultural economy of the Valley was based on dairy farming on the larger holdings, and on gardening, truck farming, and subsistence farming on the smaller holdings. Protection of the developed farmland from flooding would have permitted more intensive cultivation and higher value crops, but the distance to a major market was deemed to limit the acreage that would be so cultivated.

In addition, if flooding were prevented the remaining undeveloped land could be cleared and developed agriculturally, potentially attaining the same value as the other agricultural land in the valley. The potential value ($168 per acre) less the base value ($61 per acre) and the cost of development ($90 per acre) would leave $17 per acre in increased value attributable to flood control, for a total of $38,964.

The COE studies evaluated three protective measures: levees, channel improvements, and upstream storage. Protection by levees would have required the construction of over 14 miles of levees, protected from erosion by heavy riprap. The construction cost was estimated at $225,000. Annual maintenance, amortization, and interest charges on such a project would have been about 10 percent of the construction cost, or $22,500 annually, 160 percent of the yearly benefits ($14,000 in average annual flood damage costs).

Because of the vast amount of gravel moved by the river in flood stages, an improved channel could be maintained in the middle and upper reaches of the valley only at excessive cost. No actual costs were computed.

Likewise, the cost of a flood control storage reservoir exceeded the expected benefits. No actual costs were computed.

Bank erosion, which caused an average annual cost of $600 in lost land, could have been prevented by revetment or riprap. The estimated cost of either a brush mat revetment or rock riprap would have been $65,000. The annual cost of such a project, based on a 25-year life, would have been $4,300, exceeding the annual benefits by 360 percent.

As a result of these findings, the COE recommended to Congress that no flood control project be approved for the Skokomish River.

U.S. Soil Conservation Service, 1964

Periodic reconnaissance studies by SCS staff (principally Cowley 1958) and internal SCS reports on flooding in the Skokomish Valley culminated in an internal memorandum and summary benefit-cost study in 1964 (Paulson, J.A., 3 September 1964, personal communication).

The Cowley report (1958) identified estimated annual flood damages in the Skokomish Valley at $69,316: annual damage to 52 farms, $45,616; to County roads, bridges, etc., $15,000; to the logging industry, $7,200; to the public utility district, $1,500. The identified watershed flood problems included streambank erosion; sand and gravel deposition on pastures; flood water damage to residences, farm buildings, machinery, and stored feed; damage to transportation and public utility structures; the cost to timber companies from transportation delays; and excessive deposition on oyster beds in the Skokomish delta.

The proposed solutions included channel excavation, streambank diking and riprapping, bridge alterations, and installation of drainage floodgates. The estimated cost was nearly $3 million. Amortized over 100 years at 3-1/8 percent, and including operation and maintenance expenses, the total average annual equivalent cost was $117,575. Balanced against an estimated average annual benefit of $85,000, the benefit-cost ratio of 0.72 was below 1.0, and the project did not qualify for funding.

Puget Sound and Adjacent Water (PSAW) Study, 1970

The PSAW Flood Control Technical Committee (1970) found flooding of the Skokomish Valley to be frequent, but because the land was used almost exclusively for pasture, the resulting average annual damages were estimated at $27,000 (1966 dollars). Voluntary operation of Cushman

Reservoir by the City of Tacoma for partial flood control on the North Fork had reduced the frequency and severity of overbank flooding in the mainstem.

Three alternative flood control measures were evaluated, a storage reservoir on the South Fork, levees along the mainstem and North and South Forks up to river mile (RM) 10, and streambank protection. None of the alternatives summarized in Table 1-3 had a favorable benefit-cost ratio.

TABLE 1-3.
FLOOD CONTROL ALTERNATIVES, PSAW STUDY, 1970.

Flood Control Alternative	Estimated Development Cost (1968 $)	Estimated Annual Cost ($)	Estimated Annual Benefit (1966 $)
South Fork Storage Reservoir	22,500,000	1,100,000	25,000
Levees, RM 0.0 to 10.0	900,000	100,000	25,000
Bank Protection	300,000	17,000	1,200

Source: Flood Control Technical Committee, 1970.

The Flood Control Technical Committee recommended implementation of floodplain zoning and management measures for the entire floodplain to limit future development and to minimize future flood damages.

Skokomish River CFCMP—Preliminary Draft Plan

The Skokomish River CFCMP—Preliminary Draft Plan is the only plan undertaken by Ecology. The report provided background information on watershed characteristics, past flood control measures, regulatory programs, and conceptual flood control management options and alternatives.

The report found that no immediate, economically feasible solution will eliminate the chronic, annual flooding problem of the Skokomish Valley, or the catastrophic potential of the river jumping its banks and carving a new channel. The report recommended the following governmental measures to ameliorate the chronic problem:

- Development of a better warning and evacuation system
- Elevation of roadways located outside of the floodway.

In addition, the CFCMP recommended the following individual measures, which may require financial or technical assistance:

- Flood proofing of structures
- Agricultural practices adapted to flooding
- Bank protection measures not harmful to fish habitat.

The report concluded that the catastrophic potential should be assessed first through a detailed study of South Fork basin erosion, landslides, and sediment transport from the South Fork to

the mainstem, plus streambank erosion in the Skokomish Valley. Only then can the magnitude of the problem be identified and potential solutions be evaluated for implementation.

Skokomish River CFHMP—Volume II—Draft

The 1993 Draft CFHMP was called Volume II in recognition of work completed in the previous Ecology Plan. The activities recommended in the 1993 Draft Plan included the following:

- Maintenance of the Skokomish River to improve the flow carrying capacity of the channel, especially through constrictions such as the Highway 101 bridge. Specific recommendations included gravel removal, overbank vegetation removal, side channel enhancement, and river bank stabilization.
- Maintenance of the Valley creeks to provide riparian habitat and a fisheries resource, removing debris blockages that restrict the carrying capacity of the creeks during flood events. Specific recommendations included removing overbank vegetation, widening openings through Highway 101, removing debris blockage, improving drainage, and designating floodway.
- Implementation of flood control measures consisting of low level set-back berms and floodproofing of individual structures.
- Improvement of flood warning and emergency response procedures so that Valley residents and the Skokomish Tribe can be more active in monitoring flood levels as they occur and make informed decisions on appropriate emergency response actions. Specific recommendations included making it easier for the Valley residents to obtain information about flood conditions directly by obtaining access for the Valley residents to USGS gauge data, providing information directly to Valley residents about dam releases, and installing a flow gauge on the South Fork.

Additional recommendations related to flood warning and emergency response during dam failure included establishing a more direct way to warn residents, and contacting the Skokomish Tribe and Skokomish River Flood Control District in the event of a dam failure.

Almost all the recommendations contained in the 1993 plan are still appropriate. Much of the background and analytical material presented in the Ecology and KCM Drafts also remains accurate. Therefore, much of this current Final Draft CFHMP is based on these previous volumes, with the addition of new work completed specifically for this document. Compilation and inclusion of information from these previous CFHMPs is intended to result in a single up-to-date, definitive document. Comments on the 1993 Draft CFHMP are included with this report as Appendix C.

Skokomish River CFHMP—Draft Chapters

The June 1995 Draft Chapters report focused particularly on three areas: flood hazard identification, acquisition of flood prone property, and regulation of floodplain development. Major products presented in the report are detailed hazard maps, a database and associated mapping showing habitable structures recommended for acquisition, and detailed descriptions of three options for regulation of development in the floodplain: the conventional floodway

approach, a split floodway, and a density floodway. All material contained within the report is integrated into this Final Draft CFHMP.

South Fork Skokomish Watershed Analysis

The South Fork Skokomish Watershed Analysis, completed by the U.S. Forest Service (USFS) in June 1995, describes watershed analysis as being

> developed by forest landowners, Indian Tribes, environmental groups and state natural resource agencies. It was adopted into regulation by the Forest Practices Board in 1992.
>
> Watershed analysis is the biological and physical assessment of a watershed in order to address the cumulative effects of forest practices on specific resources (fish, water, improvements of the state). Based on this assessment, "prescriptions" are designed to protect and allow the recovery of public resources. These "prescriptions" become conditions for forest practices and are incorporated into approvals granted by the Department of Natural Resources (DNR 1995).

The South Fork Watershed Analysis presents information on beneficial uses and values of the watershed, past and current conditions, guidance for site analysis and project level planning, and information management. The two major areas in which recommendations are made for site analysis and project level planning are implementation of riparian reserves and restoration. Restoration involves the recovery and protection of ecosystem functions. A more detailed discussion of these recommendations is presented in Chapter 6.

Other Documents

Material from the other documents listed in Table 1-2 is discussed where it has been integrated into the plan.

Current Studies

Two studies are currently being completed, conclusions and recommendations from which are relevant to this report.

Watershed/Ecosystem Improvement Action Plan-Skokomish Tribe

A Watershed/Ecosystem Improvement Action Plan is currently under development for the Skokomish Watershed. The effort is being spearheaded by the Skokomish Indian Tribe and will provide a framework for identifying specific, prioritized actions and implementation strategies for the entire watershed. The Watershed Plan will provide a blueprint for government entities to focus resources for the protection, restoration, and management of the watershed, and will support legislation to implement coordinated watershed improvement initiatives. Specific products will be as follows (Skokomish Tribe 1993):

- A draft strategic plan for watershed ecosystem improvement in the Skokomish River Basin

- A final implementation plan or blueprint for watershed ecosystem improvement in the Skokomish River basin
- Public information tools, including a video, color brochure, and fact sheets
- A Skokomish River Basin Coordinating Council to guide development, implementation, and monitoring of watershed/ecosystem improvement programs
- A Wetlands Conservation Plan and implementation strategy for the Skokomish Indian Reservation
- Congressional legislation to implement comprehensive, coordinated watershed/ecosystem improvements

As of March 1995, technical information was still being gathered for the watershed plan. At that time, it was anticipated that a working draft would be issued for public and agency review by mid-1995. The tribe has indicated it would like to insert the Skokomish River CFHMP into the watershed plan (Cheney, E., 20 April 1995, personal communication)

Draft Environmental Impact Statement—Cushman Hydroelectric Project

The Draft Environmental Impact Statement (DEIS) was prepared to evaluate the environmental impacts of, and alternatives to, the proposed relicensing of the Cushman Hydroelectric Project on the North Fork Skokomish River. The Cushman Project is owned and operated by Tacoma Public Utilities (TPU). It captures runoff from approximately 99 square miles (mi^2) of the North Fork Skokomish River Watershed, approximately 40 percent of the entire Skokomish River Watershed. As a result of the project, all but approximately 30 cfs of the flows that historically passed through the North Fork to the mainstem of the Skokomish are diverted through a power tunnel to a downstream powerhouse and out to Hood Canal.

The principal objectives of the relicensing proceeding are described in the document as follows:

- Maintain production of non-polluting, renewable electrical energy
- Preserve the project's lake environment for recreational and residential uses
- Restore wild, self-sustaining runs of anadromous fish in the North Fork and mainstem Skokomish River, and enhance recreational, commercial, and subsistence fisheries based on the basin's anadromous fish
- Maintain the project's flood protection benefits
- Enhance wildlife habitat and protect wildlife populations
- Improve sediment transport and cease and reverse channel aggradation in the Skokomish River
- Protect cultural resources.

The DEIS presents four alternatives developed by the Federal Energy Regulatory Commission (FERC), and a fifth from TPU:

- **Alternative 1—No Action:** The project would continue to operate as it does today, under existing operating constraints, including a 30 cfs release required by the project's section 401 water quality certificate.
- **Alternative 2—JRP Recommendation:** This alternative was developed by the Joint Resource Parties (JRP), which consists of the National Marine Fisheries Service, Department of the Interior, Fish and Wildlife Service, National Park Service, Bureau of Indian Affairs, Washington Department of Fish and Wildlife, and the Skokomish Indian Tribe. This alternative involves installation of new hydropower facilities, protecting and enhancing native plant and wildlife habitat on 15,781 acres of land, and additional environmental enhancements including removal of the dikes on the Nalley Ranch at the mouth of the River. The primary operational change would be a cessation of diversion from the North Fork and the return of full flows to the North Fork. Releases from the reservoir would be based on reservoir operation policy, with average flows in the North Fork expected to be 782 cfs after five years.
- **Alternative 3—FERC Staff Recommendation:** This alternative was developed by FERC staff with the intent of "achieving, to the extent practicable, important elements" of the TPU and JRP recommendations. It involves installation of new hydropower facilities, a wildlife enhancement plan to protect and enhance 5,920 acres of land, and removal of the Nalley Ranch dikes. Average flows in the North Fork would be 240 cfs under this alternative.
- **Alternative 4 - (Decommissioning):** Alternative 4 involves removal of all existing project facilities as necessary. The alternative was analyzed with and without dam removal. Flows in the North Fork are expected to be 783 or 784 cfs, depending on whether dams were removed.
- **Tacoma's proposal:** Increase hydropower generation through replacing existing facilities and installing new facilities. Continue current operation of reservoirs. Implement environmental enhancements, including a series of instream fish habitat enhancements and enhancement of 3,602 acres of land for wildlife. Minimum instream flows would be regulated at 100 cfs year-round to enhance fish habitat in the lower North Fork.

In recommending Alternative 3, FERC staff concluded that

> Flooding has caused considerable problems for residents in the Skokomish River flood plain. Tacoma's Proposal and Alternative 1, no action, would have no effect on the mainstem's aggradation rate or conveyance capacity, thereby not reducing flooding. Although decommissioning the project, Alternative 4, with dam removal would increase peak flows and cause more rapid channel morphometry changes in the lower North Fork and mainstem than Tacoma's Proposal or Alternative 2 or 3, it would dramatically increase flood magnitude. Alternative 2 enhancements would increase flood conveyance capacity and

would have the most beneficial effects on reducing mainstem flood hazards; however, the near full flows to the North Fork proposed under this alternative would cause a significant loss of hydropower generation and could have significant adverse effects on mainstem fisheries.

Under Alternative 3, Tacoma would provide augmented flows to the North Fork that should expand channel capacity and increase sediment transport capacity. Tacoma would study the effects of the augmented flows to develop a mainstem capacity maintenance program and would also participate in projects in Mason County's Final Flood Hazard Management Plan. The combined actions included in Alternative 3 should make it highly effective in reducing mainstem flood hazards, but with minimal loss of hydropower generation and minimal risk to valuable fishery populations (FERC 1995).

Comments were accepted on the DEIS until March 14, 1996; a Final Environmental Impact Statement will then be prepared, and the FERC will make a decision on relicensing based on the Final EIS.

Additional discussion of the re-licensing process and communication between the County and PAC and FERC is presented in Chapter 6.

PLAN ORGANIZATION

As described above, this CFHMP is organized according to guidelines presented in RCW 86.26 and WAC 173-145. The following is a brief summary to material included in each of the chapters:

Chapter 2: "Study Area Characteristics" presents a detailed discussion of the physical and socioeconomic characteristics of the watershed. This chapter provides the background necessary to develop flood hazard management alternatives.

Chapter 3: "Hydrology of the Skokomish Valley" discusses the surface water hydrology, groundwater hydrology, and geomorphology of the Skokomish Valley.

Chapter 4: "Flood History" summarizes historical flooding, flood-related damages, and previous flood hazard management activities in the Valley.

Chapter 5: "Regulatory Setting" presents a summary of regulatory programs affecting implementation of this CFHMP and describes the permitting process. Suggested changes to existing County Ordinances are also presented.

Chapter 6: "Flood Hazard Management Alternatives, Analysis, and Recommended Actions" is a detailed discussion of the issues, analyses completed to develop alternatives, and specific actions recommended to address each issue.

Chapter 7: "Funding" presents funding options for implementing actions recommended in the plan.

Chapter 8: "Environmental Impacts" describes the effect of each of the recommended actions on fisheries and wildlife; scenic, aesthetic, and historic resources; navigation; water quality; hydrology; and recreation.

CHAPTER 2.
STUDY AREA CHARACTERISTICS

The Skokomish River is one of the southernmost rivers in the Puget Sound Region (see Figure 2-1). It collects drainage from approximately 240 square miles of the southeastern portion of the Olympic Peninsula and drains into southern Hood Canal, an arm of Puget Sound. The drainage basin is steep and rainfall is high. The upper basin is divided into two major subbasins (Figure 2-2). The 104-square-mile South Fork subbasin is largely undeveloped but has been subjected to extensive clearcut timber harvesting. Vance Creek is a smaller tributary to the South Fork Skokomish that drains approximately 25 square miles.

Lake Cushman is the dominant feature in the 118-square-mile North Fork subbasin. Since 1926, flow from the lake into the lower North Fork Skokomish has been controlled by two dams that divert the majority of flow out of the basin to a hydroelectric power plant located on Hood Canal approximately 3 miles north of the river mouth. Homes and cabins dot the shore of the lake. The public has access to the lake and uses it extensively for recreation.

The mainstem Skokomish River flows from the confluence of the two forks through a wide, flat valley. US 101, built on an embankment several feet above the valley floor, crosses the river approximately 5 miles upstream of the mouth. SR 106 crosses the river approximately 2 miles upstream of the mouth and traverses the Skokomish Indian Reservation.

The primary study area for this CFHMP is the Skokomish Valley, which experiences the majority of flood damage. For the purposes of this report, the Skokomish Valley is defined as extending from the Skokomish delta on Hood Canal upstream to the section of the river known locally as Five Mile Corner, approximately 1.4 miles above the confluence of the North and South Forks. The secondary study area is the entire Skokomish River basin.

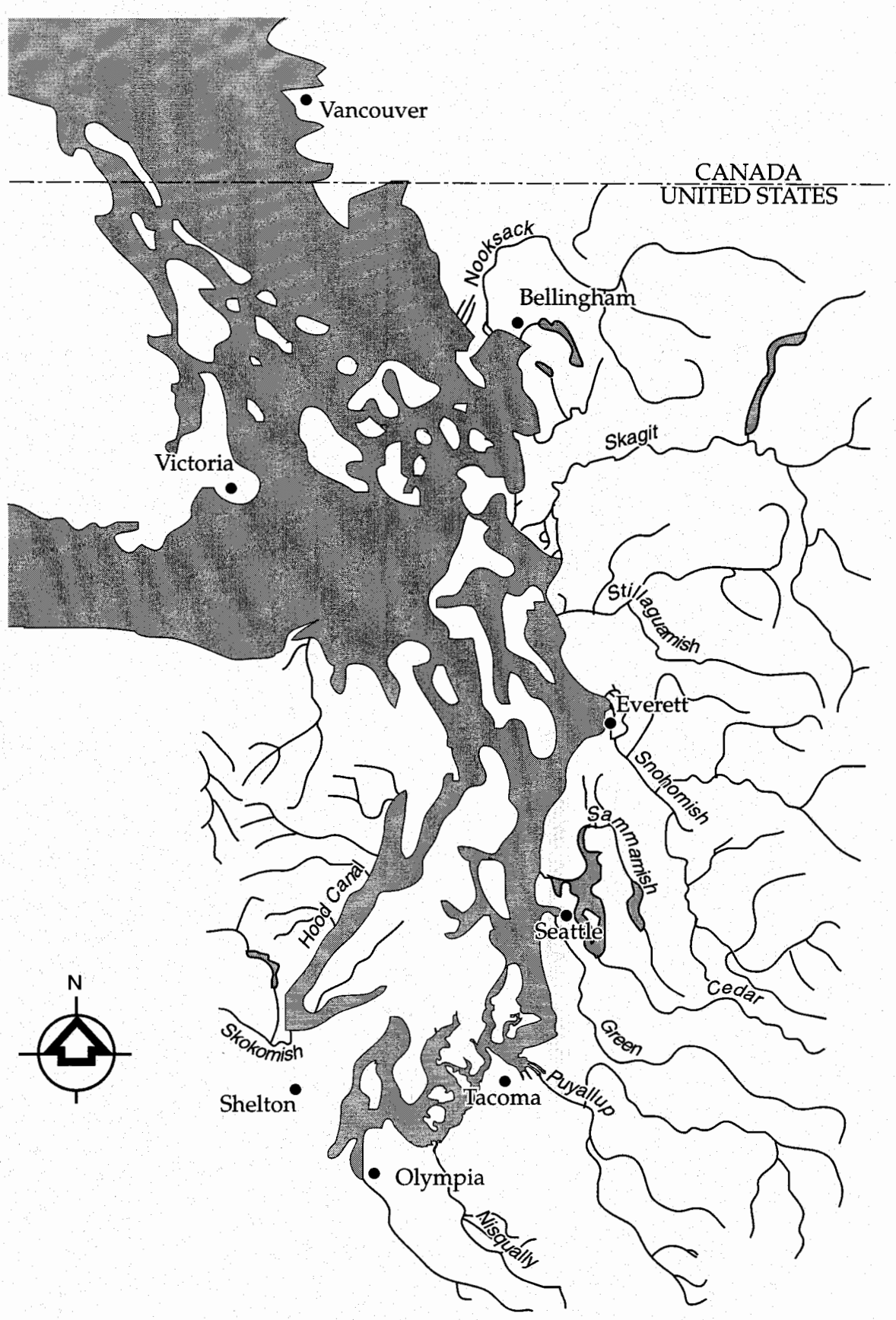
The Skokomish River watershed has been described in previous reports: the 1988 Preliminary Draft CFHMP; the 1993 Volume II CFHMP; and the June 1995 South Fork Skokomish Watershed Analysis. Material presented in this chapter is taken largely from these references.

PHYSICAL CHARACTERISTICS

Environmental factors that influence the evolution of watershed's landscape are critical to flood hazard management because they help determine a river's location and shape, its range of flows, the amount and size of sediment it carries, and the dimensions of the floodplain. The following sections describe the climate, physiography, soils, and geology of the study area.

Climate

The climate of the basin is generally typical of the Puget Sound region, which is strongly influenced by the Olympic Mountains and storms forming over the Pacific Ocean. Ocean storms typically move across the Olympic Peninsula from the southwest to the northeast. The Olympic Mountains shelter the basin from the full effect of Pacific Ocean storm systems. A gap in the coast range system between the Willapa Hills and the Olympic Mountains south of the basin allows limited movement of coastal storms into the southern Skokomish basin and the Puget Sound basin in general.



KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-1. RIVERS OF THE PUGET SOUND REGION

SOURCE: Federal Energy Regulatory Commission, November 1995.

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-2. SKOKOMISH RIVER WATERSHED

Precipitation cycles are annual, and some long-term trends have been reported. The climatic cycle is characterized by cool, wet winters and cool, dry summers. The dry season runs from July through August, followed by a rainy season reaching its peak in November through January. More than three-fourths of the annual precipitation, mostly rainfall with some snow, occurs from early October through March. Annual precipitation records from a weather station on the east side of the Olympic Peninsula from 1931 to 1973 reveal relatively dry periods in the mid-1930s and early 1940s, and a generally wetter period since (Haushild et al. 1978).

Mean annual precipitation across the Skokomish basin ranges from 200 to 220 inches per year, on the Olympic crest in the upper watershed, to 80 to 90 inches per year, in the Skokomish Valley, and 75 to 80 inches, at the mouth of the river (Phillips 1986; Molenaar and Noble 1970) (see Figure 2-3). Average precipitation for the basin as a whole is about 133 inches per year. Records kept at Cushman Dam show an average annual precipitation of 100.25 inches, with extremes of 132.09 inches and 69.24 inches. Peak daily precipitation records of 6 to 7 inches have occurred between November and February (Phillips 1986). Given the rugged terrain and scoring of the landscape by river canyons, rainfall can be highly erratic between subbasins.

During the winter, much of the precipitation in the mountainous part of the Skokomish River basin above 1,000 feet occurs as snow. Snow at elevations above about 2,500 feet remains as snowpack until spring and early summer, when it melts and provides most of the water to the streams during the dry summer months. Snow and rain are common between 1,000 and 2,500 feet. Generally shallow snowpacks (less than 15 inches deep) accumulate and melt quickly several times each winter as alternating cold fronts and warm fronts cross the area (Harr 1981). These rain-on-snow events can cause flooding in the valley. Figure 2-4, prepared for the Watershed Analysis, shows the precipitation zones for the South Fork Watershed.

Temperature

Temperatures vary across the basin due to topographic conditions; records kept at Cushman Dam reflect the conditions on the plateaus adjacent to the Skokomish Valley. Typical of the Puget Sound area, the highest temperatures occur in July (mean maximum 78.3°F, mean minimum 47.8°F), and the lowest in January (mean maximum 43.7°F, mean minimum 30.5°F). The extremes recorded at Cushman Dam are 104°F and -2°F (Phillips 1986). No temperature data is available for the Skokomish Valley itself. Temperature has no direct effect on flooding, but does influence rainfall and snowfall patterns, which do affect flooding.

Evaporation

No evaporation measurements are known to have been made in or near the Skokomish basin. Based on studies conducted in Seattle (45 miles northeast) and Puyallup (45 miles east), the annual evaporation from a Class A pan is estimated to be 25 to 35 inches. Annual evaporation from lakes and reservoirs is estimated to be 20 to 25 inches. Average monthly evaporation rates range from less than an inch from November through February, to over 6 inches during July (Phillips 1968).

Wind

No meaningful wind information is available for the study area; the closest monitoring stations within the Puget Sound basin are in Olympia (25 miles southeast), Tacoma (35 miles east), and

Seattle. In general, however, the prevailing winds are south to southwest during the winter, and north to northwest during the summer. The strongest winds occur during the winter, when intense storms move inland from the Pacific Ocean. Extreme wind velocities (at 30 feet above the surface) can exceed 55 mph once in 2 years; 80 mph once in 50 years; and 90 mph once in 100 years (Phillips 1968). Wind patterns have no direct effect on flooding.

Physiography

The physiography, or physical geography, of the Skokomish basin is dominated by the northwest-to-southeast ridge and canyon systems of the two main forks of the river and the major tributaries (LeBar Creek and Vance Creek). For the most part, the minor tributaries form northeast-to-southwest secondary ridge and canyon systems. Lake Cushman, a 4,000-acre, 8.4-mile-long hydropower impoundment of the City of Tacoma, is a major feature of the North Fork (Ames and Bucknell 1981; Bortleson et al. 1976; Williams et al. 1975).

The steep watershed terrain is an important factor in determining the location of unstable river canyon slopes, which contribute to a high bedload and an aggrading river bed, which in turn produce increasing frequency and severity of flooding.

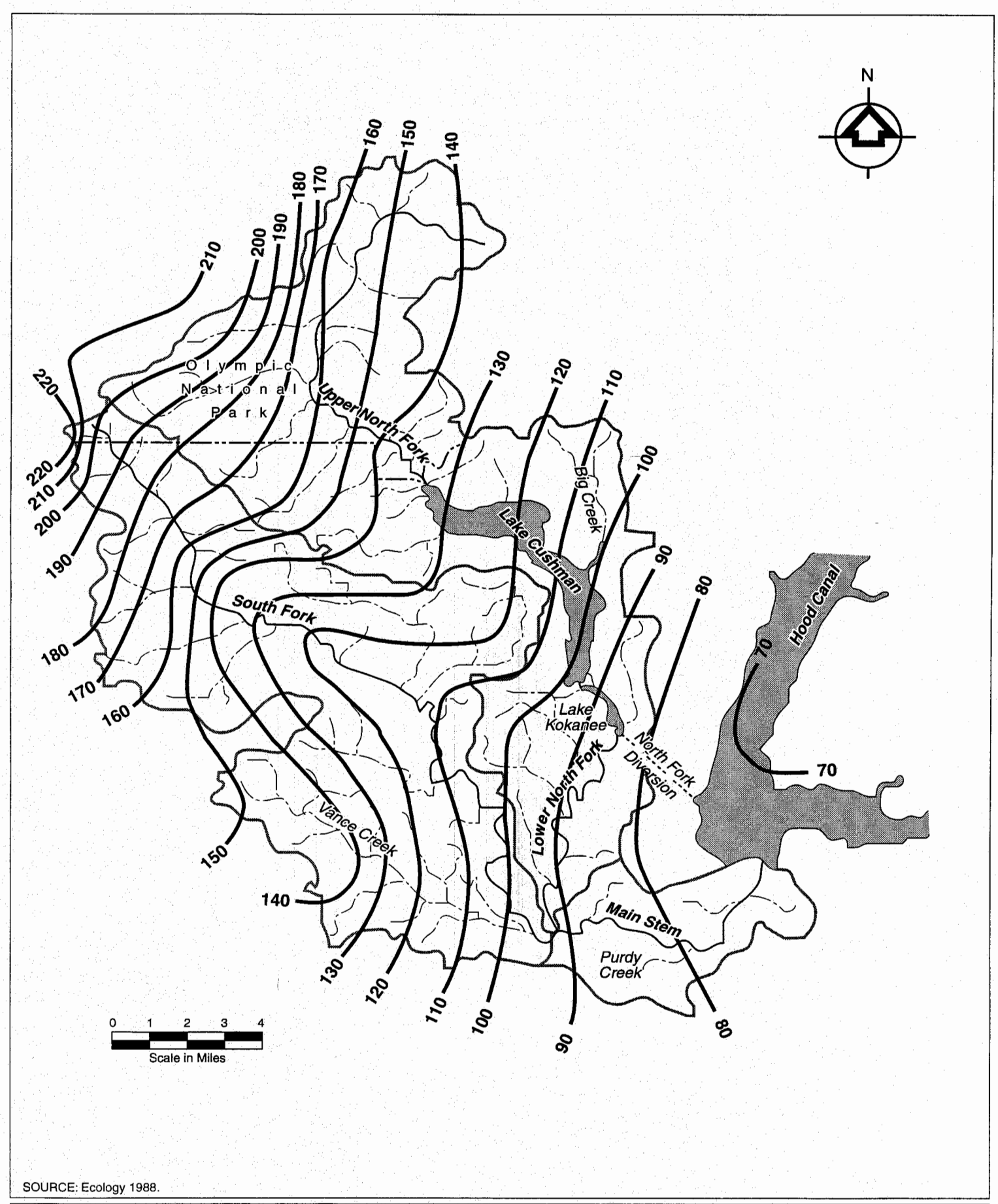
Topography

With the exception of the Skokomish Valley and its adjacent plateaus, the basin is typified by steep, rugged terrain (Williams et al. 1975). The northwestern limits of the basin run along the Olympic Mountains between the Pacific Ocean and Puget Sound at elevations of 4,000 to 6,000 feet. The lower basin is characterized by steep streamside slopes and level to rolling plateaus. In the upper watershed, the valley walls are steep and the ridge tops sharp. These slopes have been deeply scored by numerous small mountain streams. The streams discharge into the three principal tributaries, which flow through deep, narrow valleys and gorges to the head of the Skokomish Valley near the confluence of the North and South Forks (Cowley 1958).

The Skokomish Valley is generally characterized as flat, although it exhibits the undulating topography common to the floodplains of the major Puget Sound basin lowland rivers. Additionally, side channels to the present riverbed remain from pre-settlement times. The valley is about 9 miles long and varies in width from ½ mile at its upper end to more than 2 miles at the river mouth on Hood Canal.

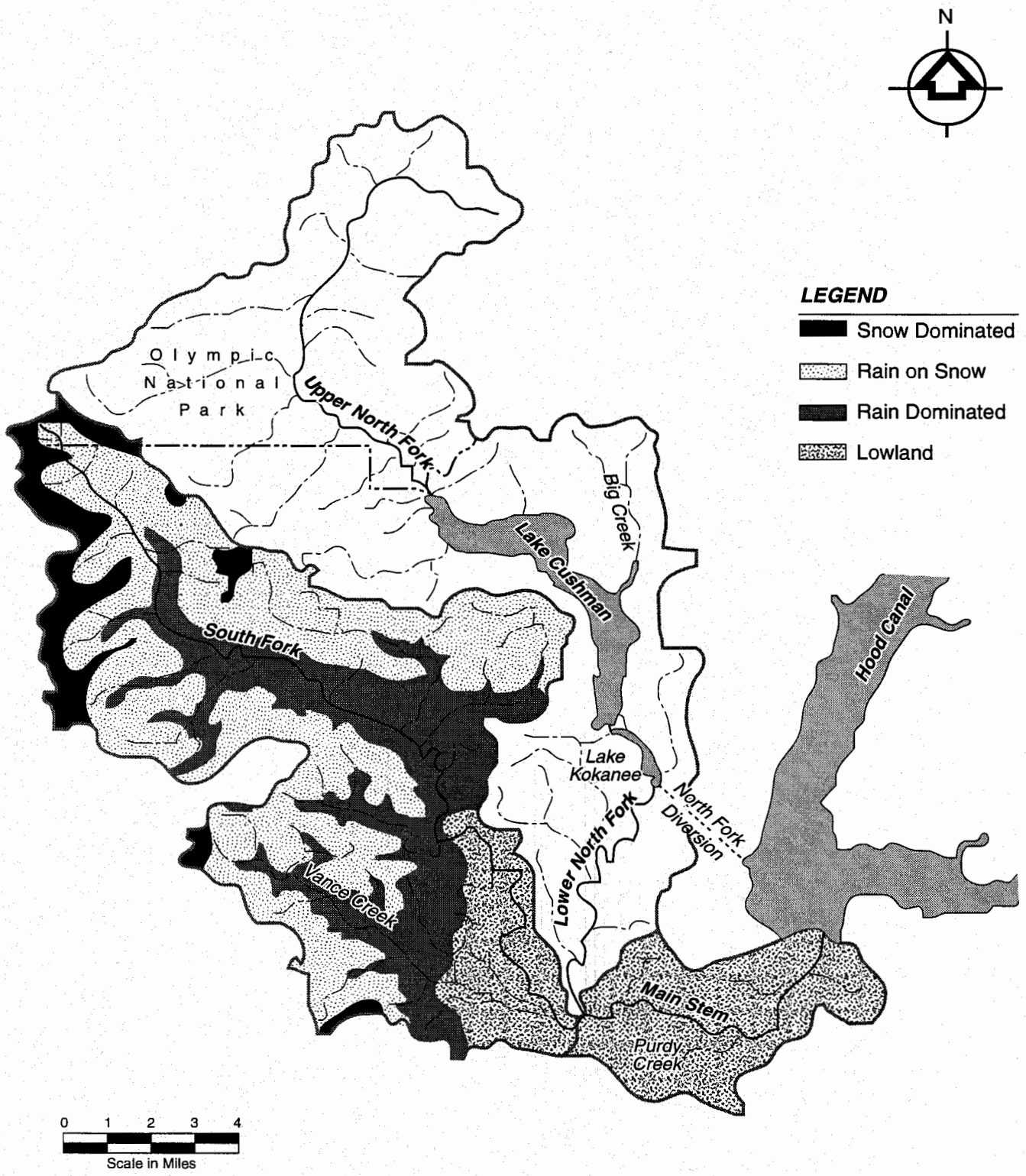
The gradient of the river is about 0.03 percent from the mouth, RM 0, upstream to RM 2; that is, the riverbed rises as the river itself flows downstream. Between RM 2 and RM 2.6, 5- to 10-foot high natural berms have been deposited, probably through the interaction of tidal fluctuations and river discharge. Between RM 2.6 and 4.8 the gradient is -0.14 percent, with natural berms up to 10 feet high between RM 4.8 and RM 5.5. From RM 5.5 up to RM 8.6, just below the North Fork South Fork confluence, the gradients are -0.19 percent from RM 5.5 to RM 7.2, +0.27 percent from RM 7.2 to RM 7.5, and -0.33 percent from RM 7.5 to RM 8.6.

A 1 percent gradient equals a 1-foot rise in 100 feet, considered the minimum gradient for adequate drainage of engineered structures such as roadside ditches and gutters. The gradient of the valley is substantially less than 1 percent, and thus has poor drainage of flood waters.



SOURCE: Ecology 1988.

KCM 1917 First Avenue Seattle, Washington 98101	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-3. MEAN ANNUAL PRECIPITATION (INCHES)— SKOKOMISH RIVER WATERSHED



SOURCE: U.S. Forest Service, 1995.

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-4. SOUTH FORK AND MAIN STEM PRECIPITATION REGIMES

Surface Drainage Patterns

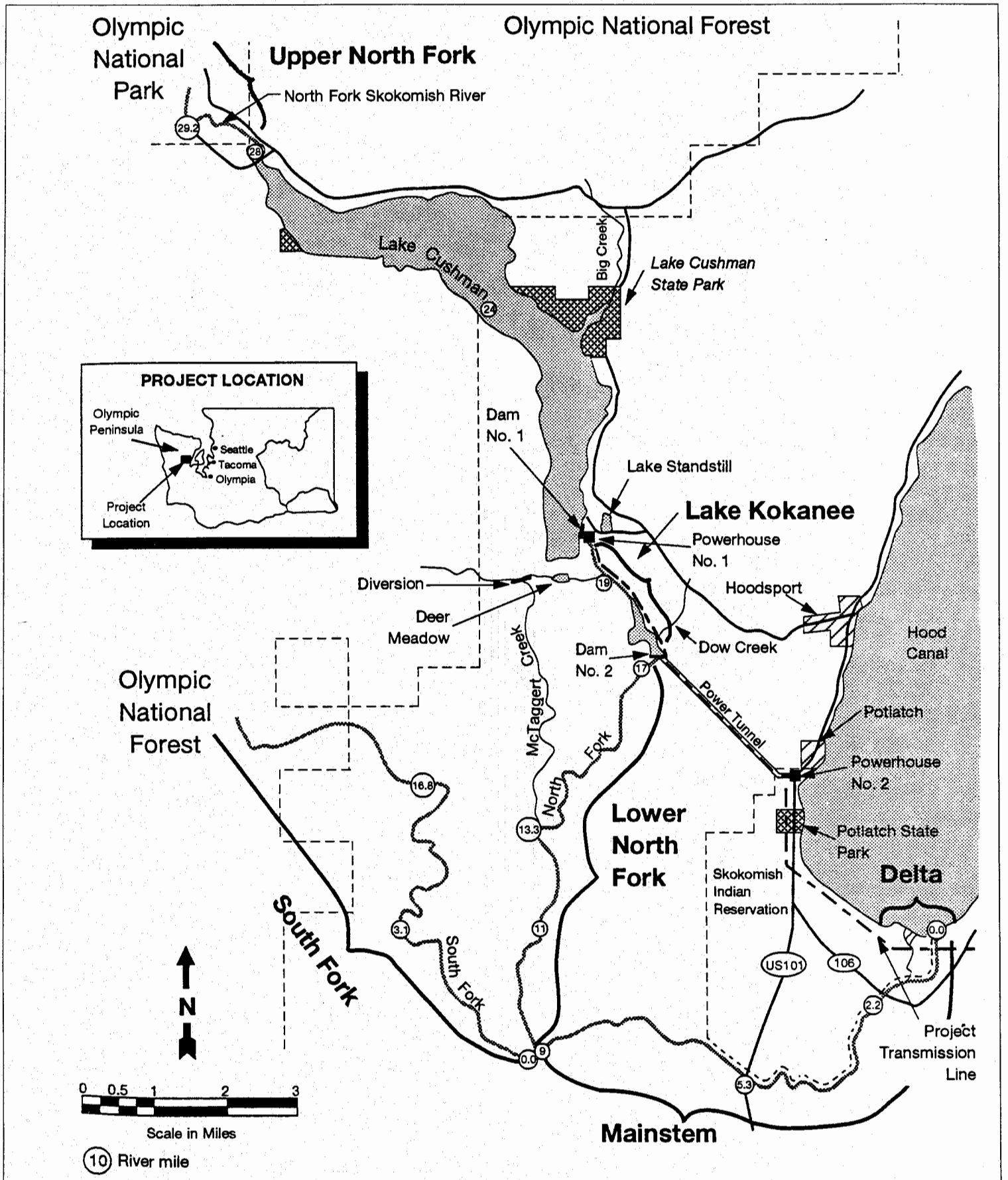
The Skokomish River system is composed of 9.0 miles of mainstem, 33.3 miles of North Fork, 27.5 miles of South Fork, and 270 miles of tributary streams. Vance Creek (11.0 miles) is the most important tributary for fisheries; other important tributaries are Purdy, Brown, LeBar, and McTaggert creeks (Williams et al. 1975). River mileage (RM) locations of prominent features are listed in Table 2-1 and shown in Figure 2-5. Additional river mile information is presented in Appendix LL.

TABLE 2-1.
RIVER MILE LOCATIONS OF PROMINENT RIVERINE FEATURES, SKOKOMISH BASIN

Stream Number [a]	Stream Name	Feature	River Mile
0001	Skokomish River	Mouth	0.0
		SR 106 highway bridge	2.2
		Purdy Creek (16-0005)	4.1
		US 101 highway bridge; gauging station 12-0615	5.3
		Powerline; former gauging station 12-0615; water quality station 16A070	6.0
		North Fork - South Fork confluence	9.0
0001	North Fork (river mile sequence continues from mainstem)	Confluence with South Fork	9.0
		gauging station 12-0595	10.0
		McTaggert Creek (16-0105)	13.3
		Lower Cushman Dam (Lower Lake Cushman, aka Lake Kokanee)	17.3
		Lake Cushman Dam	19.6
		Olympic National Forest boundary	24.0
		Lake Cushman inlet	28.0
		Olympic National Forest boundary	28.1
		Mason-Jefferson county boundary	37.9
		headwaters	41.9
0011	South Fork	Mouth - confluence with North Fork	0.0
		Vance Creek (16-0013)	0.8
		gauging station 12-0605	3.1
		Olympic National Forest boundary	3.5
		Forest 2202 road bridge	6.8
		Brown Creek (16-0047)	12.8
		LeBar Creek (16-0053)	13.5
		Olympic National Park boundary	26.4
		Mason - Jefferson county boundary	27.0
		Headwaters	27.5

a. Stream numbers are 6-digit numbers, e.g. 12-3456, the first 2 digits indicating the basin number and the remainder representing the specific stream within the basin; Skokomish basin streams are numbered 16-0000, etc.
b. The head of tidal influence is taken as a mean annual high tide at low instream flow.

SOURCES: Ames and Bucknell, 1981; Fleskes and O'Connor, 1980; Williams et al., 1975.



SOURCE: Federal Energy Regulatory Commission, November 1995.

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 2-5. CUSHMAN HYDROELECTRIC PROJECT AND SKOKOMISH RIVER SYSTEM

The Skokomish Valley is drained by a network of old meanders, creeks (Swift, Hunter, Weaver, and Purdy Creeks; see Figure 2-6), and plowed-over sloughs. The sloughs, being partially filled, are clearly evident only during low-intensity flooding. The old meanders have been partially filled, limiting their capacity to carry flood flows and contributing to locally chronic high water tables and flooding.

Tidal Influenced Area

Tide levels affect flooding by causing a backwater effect, slowing the discharge of floodwaters to Hood Canal. Cummans (1974) determined the upper limit of tidal influence to be "some point below RM 5.3" and that the "exact location of the point was not a significant factor" in his study of flood profiles of the lower Skokomish River. This is not to say that tidal influence is not an important factor in flooding of the Skokomish delta area, only that the exact location of the upper limit of tidal influence is not important.

Table 2-2 shows the average tidal levels at the tide gauge at Union at the mouth of the Skokomish River and the corresponding land-based elevations.

TABLE 2-2.
TIDAL ELEVATIONS AT MOUTH OF SKOKOMISH RIVER

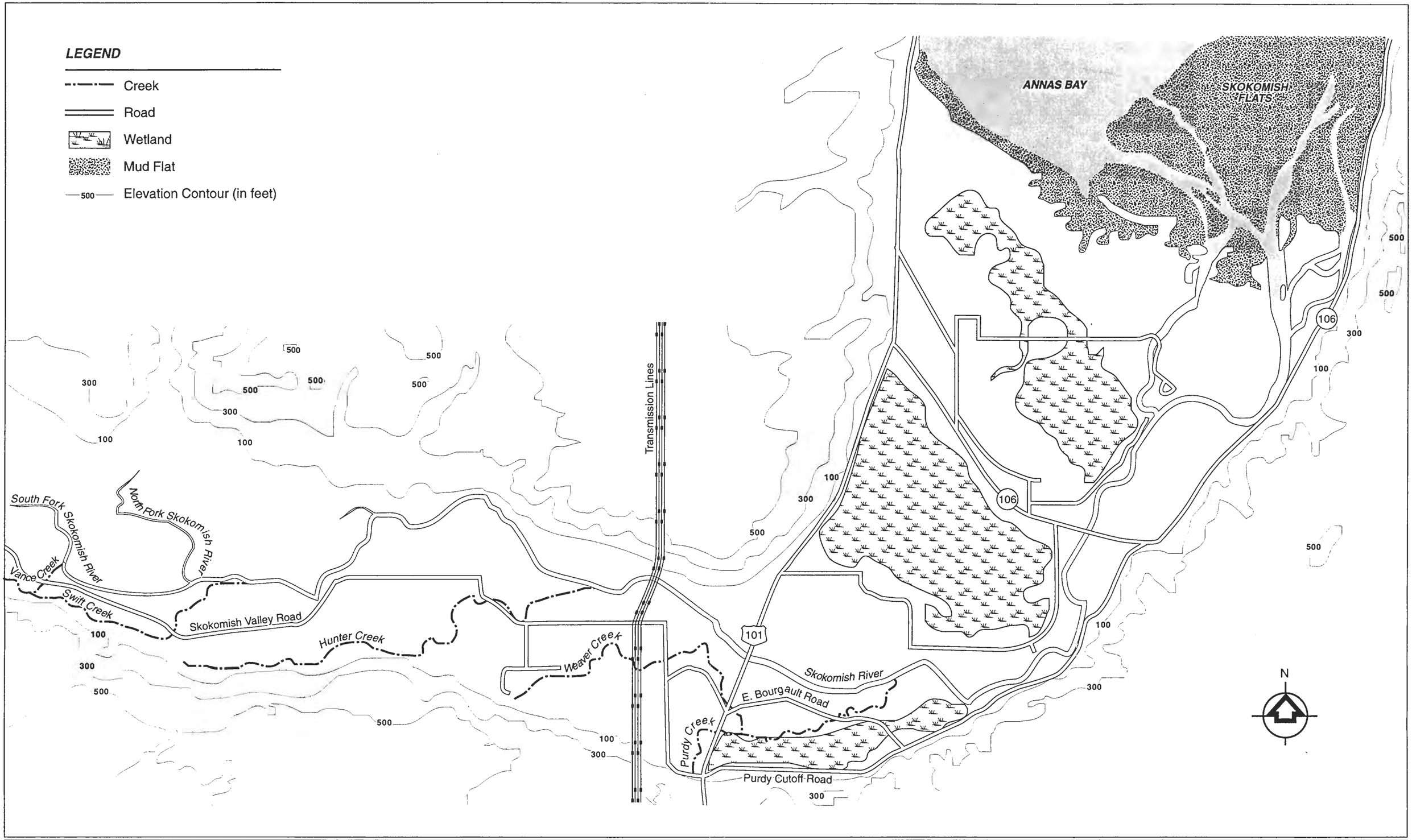
	Tidal Elevation (Gauge Datum)	1929 Datum Elevation
Mean higher high water	11.8	4.9
Mean high water	10.8	3.9
Mean tide (sea) level	6.9	0.0

Under normal conditions (mean high water), direct tidal influence will extend up the Skokomish River to the point where the river bed elevation is 3.9 feet, and under extreme conditions (mean higher high water) to the point where the river bed elevation is 4.9 feet. Based on FEMA's 1983 river bed profiles, these locations are RM 3.7 and RM 3.8 respectively. Indirect tidal influence will occur above this location to a variable extent, depending on river flow volumes.

No information on the upper limits of salt water influence in the delta is available. Salt water influence has no known effect on flooding in the Skokomish Valley.

Soils

The soils of the Skokomish River basin are typical of the mountainous soils of the east slope of the Olympic Peninsula. These soils have a high erosion potential due to slope steepness and high rainfall rates. These soils are easily disturbed by activities such as road-building and other earth-moving activities or clearcut logging. Soils on forest slopes are relatively shallow; soils on the plateaus are deeper. In general, the upland soils on slopes are well drained, with low-to-moderate water retention, and high infiltration rates (ONF 1986, Rushton 1985). Because of the Basin's unstable soils and steep slopes, land sliding and debris sliding also contribute sediments to the river system (Cowley 1958). These materials all contribute to river bed aggradation, which in turn exacerbates flooding.



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Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 2-6.
SKOKOMISH VALLEY CREEKS

The soils of the primary study area, the Skokomish Valley, are deep alluvial soils, many of which have relatively high agricultural Capability Class ratings and substantial limitations for development, as summarized in Table 2-3 (Ness and Fowler 1960). Alluvial soils, deposited by successive flooding of river valleys, typically have high agricultural value because they contain the variety and abundance of minerals necessary for plant growth not commonly found in soils that developed in-place from a single source. Thus the flooding of the Skokomish Valley is also the source of its agricultural productivity.

TABLE 2-3.
SOILS CHARACTERISTICS, SKOKOMISH VALLEY, MASON COUNTY, WASHINGTON

Soil Type Code	Name	Capability Class	Development Limitations
Skokomish Valley above US 101			
Dg	Dungeness fine sandy loam	IIw	The Dungeness Series has severe limitations for on-site sewage disposal and building construction due to flooding and wetness; from November through April the depth to the water table is 2 to 4 feet and less when flooding occurs.
Dh	Dungeness fsl, shallow	IIw	
Dk	Dungeness silt loam	IIw	
Pa	Pilchuck gravelly loamy sand	VIIs	The Pilchuck series has severe limitations for on-site sewage disposal and building construction due to flooding and wetness; from November through April the depth to the water table is 2 to 4 feet and less when flooding occurs.
Pb	Pilchuck loamy sand	VIs	
Pc	Pilchuck sand, shallow	VIIs	
Ra	Riverwash	VIII	Riverwash is considered unsuitable for any development due to its proximity to the river and frequency of flooding.
Skokomish Delta below US 101			
Dg	Dungeness fine sandy loam	IIw	See notes on Dungeness series above.
Dk	Dungeness silt loam	IIw	
Mg	Mukilteo peat	IIIw	The Mukilteo series has sever limitations for on-site sewage disposal and building construction due to wetness and low strength; from October through May the depth to the water table is 1.5 to 3 feet and less during flooding.
Mh	Mukilteo peat, shallow over gravel	IVw	
Pd	Puget silt loam	IIIw	The Puget and Skokomish soils have the same severe limitations as the Dungeness and Pilchuck soils as described above.
Sr	Skokomish silt loam	IIw	

SOURCE: Ness & Fowler, 1960
US Soil Conservation Service Soil Interpretation Record sheets for Mason County.

The water table in the Skokomish Valley is close to the ground surface. High water tables are a natural occurrence in river valley floodplains. Extreme high water tables at the ground surface are a temporary, natural effect of flooding. Development limitations created by the locally high groundwater table and the alluvial soils include impairment of sewage disposal leach field performance throughout the year; and reduction in soil load-bearing strength for building foundations and roadways.

Approximate boundaries of wetlands in the Skokomish Valley were identified during a wetlands inventory completed for the 1993 Draft CFHMP. A discussion of types and distribution of wetlands is presented in the inventory report, included here as Appendix D.

Erosion

An erosion assessment of the South Fork Watershed was completed as part of the South Fork Skokomish Watershed Analysis to provide local scope and scale to erosion patterns, examine the influence of land management on erosion processes, and identify and prioritize, if necessary, watershed restoration opportunities. The report indicates that, aside from relatively brief periods following occasional natural events, the system was relatively stable prior to the earliest European settlement in the Skokomish River Valley.

The Watershed Analysis concludes that:

> Sediment inputs to the system have historically come as short pulses from mass wasting events on high gradient slopes. Probably more sediment to lower gradient streams from bank, inner gorges, and reworking and redistribution of alluvium and glacial outwash. Short-term inputs of sediment initially reduce fish productivity but can also enhance habitat. However, in combination with natural slope and bank instability, human activities such as road building, timber harvest, and residential development can create chronic sediment problems.
>
> Surface erosion within the watershed is primarily a result of side cast road construction techniques. There are approximately 354 miles of roads on the National Forest lands and about 116 miles of state, county or private roads within the watershed.
>
> For example, our analysis has revealed that timber harvesting activities including road building has diminished water quality by increasing sediment input. The Watershed Improvement Needs (WIN) Inventory identified over 2,500 erosion sites within the basin. These erosion sites range in size from 1/4 to approximately 5 acres and are mostly surface erosion sites. Approximately 5 percent of these sites are mass wasting events. Ninety five percent of these sites are located adjacent to roads. Sixty five percent of these erosion sites affect the fish habitat and water quality. The most probable effect is pool filling and aggradation.
>
> Significant acres of upland terrestrial habitat have been altered or degraded as a result of road construction, timber harvest techniques, and fire management activities. As mentioned earlier, most road construction was accomplished by side-casting soil and rock debris from cutslopes to fillslopes. These erosion sites are difficult to revegetate. Approximately 1400 acres have been affected. In the lower Skokomish valley, terrestrial habitat has also been removed or altered to accommodate agricultural activities and scattered homes (USFS 1995).

The magnitude of the sediment input into the South Fork system was not quantified in the Watershed Analysis. This information is important in completing a sediment budget for the watershed. Order-of-magnitude sediment budgets can be coupled with field monitoring of sediment transport volumes to quantify the effect of upper basin sediment production on aggradation of the Skokomish River channel.

Geology

The geology of the area is discussed in the following sections, including descriptions of geologic processes and the resulting geologic formations, minerals, and geologic hazards.

Bedrock Geology

The oldest exposed rocks in the Skokomish Valley are basaltic flows of Eocene age (between 38 and 58 million years old) in the foothills of the Olympic Mountains. These basalt flows are overlain by sedimentary rocks in the subsurface. During the Pliocene Epoch (2 to 5 million years ago), these rocks were uplifted to form the Olympic Mountains; the same uplift occurred in the Cascade Range. The downwarp between the two ranges forms the Puget Lowland. Mason County and the Skokomish Valley are in the southwestern portion of the downwarped area, which is the repository of sediments eroded from the Olympic Mountains.

Pleistocene and Recent Geology

Most of the present-day landforms in the Skokomish valley area were formed during the Pleistocene Epoch (between 2 million and 10,000 years ago). This period is known as the Ice Age because of the ice-sheet glaciation that marked the interval. Mason County and the Skokomish valley experienced four to six glaciations from the ice sheet that originated in the Coast Range of British Columbia and covered the entire Puget Lowland. Only the last of these glaciations, known as the Vashon Stade of the Fraser Glaciation, is well documented in the Skokomish valley. One pre-Vashon deposit, the Skokomish gravel, is significant to the groundwater resources of the area.

The Skokomish gravel, formally defined by Molenaar and Noble (1970), is a thick and widespread sequence of stream-laid detritus derived from the Olympic Mountains. The Skokomish gravel underlies much of the plain north and south of the Skokomish Valley, and probably underlies the alluvium in the Skokomish Valley itself. Good exposures of the gravel occur in the bluffs along the south side of the Skokomish Valley from U.S. 101 to about 3 miles east of the town of Union on Hood Canal. These exposures show a sequence of oxidized sand and gravel with interbeds of clay and silt. Buff-colored silt and clay with peat-bearing horizons are also common. Molenaar and Noble interpreted the buff-colored silt and clay to correlate with the Kitsap Formation, sediments derived from the Mount Rainier and southern Cascade region. The Skokomish gravel is believed to have been deposited during an interglacial period because of the oxidation and interfingering with the Kitsap Formation. The thickness of the Skokomish gravel diminishes eastward away from the Olympic Mountains. This unit is a productive aquifer in areas where it occurs below sea level.

The Vashon Stade of the Fraser Glaciation left a mantle of glacial till over the landscape and streamlined much of the topography, particularly on the plain south of the Valley, in a northeast-southwest direction. Three units are associated with Vashon drift: advance outwash,

till, and recessional outwash. Advance outwash sand and gravel deposits are widespread and may be as much as 200 feet thick. Till, or hardpan, is typically gray to bluish gray, a compact and unsorted mixture of cobbles and pebbles in a matrix of sand, silt, and clay. Till is common at or near the surface of the drift plains. Recessional outwash forms the predominately sedimentary sequence underlying the outwash plain between Shelton and the Skokomish Valley. The outwash is composed chiefly of poorly sorted sand, gravel, and clay.

During post-glacial times the Skokomish River has downcut through the till plain to form its current valley. In the process, alluvium carried by the river has been deposited in the valley. This alluvium, combined with the older sand and gravel deposited during the glacial period, make up the principal aquifer in the Skokomish Valley.

Minerals

Few mineral deposits are known in the Skokomish basin. No oil or gas exploration has occurred in the Skokomish basin (McFarland 1983). The mid- to upper portion of the basin lies within the Olympic Peninsula limestone belt, but there has been no commercial development. The lower portion of the basin lies within a zone of sand and gravel deposits; again, there has been no commercial development. No other nonmetallic minerals are known in the basin (Valentine and Huntting 1960). Copper and manganese (and associated metallic minerals such as iron and zinc) are known from the North Fork basin, particularly from the ridges along the divide to the Hamma basin, but there has been no commercial development (Huntting 1956). WDFW has issued a number of HPAs for instream gold mining in the mainstem; no information is available on production. This level of minerals exploration and exploitation does not appear to have any effect on flood characteristics.

There are no known studies of the sand and gravel resource in the Skokomish basin or river system, or of sand and gravel transport. Bell (1982) reviewed sand and gravel transport and the potential effects of the then-proposed South Fork hydropower dam in a theoretical context, but conducted no substantive field studies or observations. Anecdotal reports indicate that the Skokomish River carries a relatively high bedload of sand and gravel.

Geologic Hazards

The canyon slopes edging the Skokomish Valley are classified as potentially unstable, except for the right bank slopes below RM 3; for the most part this has little or no direct consequence for flood hazard management except where the river cuts close against a potentially unstable canyon slope (Smith and Carson 1977). At these locations, land management and land development practices could result in slope failures, partially blocking the river. Most slope failures occur during periods of heavy winter rainfall (Canning 1985), coinciding with peak river flows and flood events. Four locations where the mainstem flows close against a potentially unstable slope were identified in the 1988 Preliminary Draft CFCMP.

The first such area is along the right bank in the vicinity of RM 1, where a Class 2 slope rises from the floodplain to the plateau top. Class 2 slopes are defined as stable under normal conditions, but which may become unstable if disturbed by human activities, by oversteepening, or by seismic shaking (Smith and Carson 1977). Here the slopes are buffered from the river by SR 106. (Slope Class is a means of categorizing land into generalized levels of stability or instability ranging from Class 1-most stable-to Class 5-least stable.)

The second is along the right bank between RM 2.9 and RM 3.7, where a Class 3 slope rises from the floodplain part way up the slope and is surrounded by Class 2 slopes. Class 3 slopes are defined as areas inferred to be unstable because they are underlain by weak, unstable materials with a history of landsliding (Smith and Carson 1977). Here too the slopes are buffered from the river by SR 106.

The third is along the left bank between RM 5.8 and RM 6.1 in the vicinity of a power transmission line, where Class 3, 4, and 5 slopes rise to the plateau top. Class 4 slopes are defined as former landslide areas, including relatively large slumps, flows, and slides of soil, rock, and debris, which may be reactivated by excavations, slope modifications, or seismic shaking. Class 5 slopes are defined as known areas of recently active slope failures, usually within the past 50 years (Smith and Carson 1977). Here, Sunnyside Road has been benched into the canyon slope and the river flows against the base of the canyon slope.

The fourth is along the left bank between RM 7.6 and RM 7.7 in the vicinity of the confluence of Stream 16-0008, where a Class 4 slope extends part way up the slope (Smith and Carson 1977). Here the river flows against the canyon slopes.

BIOLOGICAL CHARACTERISTICS

Biological characteristics of the valley have developed as a direct result of the local hydrologic regime. The Skokomish River system supports a great diversity of plant and animal species. Flooding can have both positive and negative effects on the regional ecosystem. The following sections describe the local ecology, fisheries, wildlife, and special plants, animals, and ecological communities.

Ecology

The Skokomish basin lies within the greater Puget Sound basin. The Skokomish headwaters lie within the *Picea sitchensis* (Sitka Spruce) forest ecosystem, with the remainder of the basin within the Puget Sound *Tsuga heterophylla* (Western Hemlock) forest ecosystem (Franklin and Dyrness 1973). Thus, with minor exceptions, the basin is covered by various types of conifer forests. The largest exception is the primary study area, the Skokomish Valley, which in its pre-settlement state was a riparian floodway dominated by a mix of western redcedar and various broadleaf trees.

Forest practices were examined in detail as part of the 1993 Draft CFHMP. The chapter that dealing with Forest Practices is included with this CFHMP as Appendix E. The following sections are taken from the 1988 Preliminary Draft CFCMP.

South Fork

Presently, much of the South Fork basin lies within the Shelton Cooperative Sustained Yield Unit (Shelton CSYU) of the Olympic National Forest and adjacent industrial timber lands of Simpson Timber Company. The Olympic National Forest portion of the Shelton CSYU has been extensively clearcut in recent decades, leaving the forest in early successional stages. The South Fork basin within the Shelton CSYU appears to be about 80 percent clearcut (based on visual estimates obtained during flights over the area). The intensity of timber harvest in the Shelton CYSU has provoked great controversy over the potential adverse effects on fisheries, water

quality, and flooding. The Skokomish Indian Tribe initiated a lawsuit against the Olympic National Forest in 1982, which was not carried to completion because the Tribe lacked the necessary financial resources. The issue remains unresolved.

North Fork

In contrast, much of the North Fork basin lies within the Olympic National Park. Here the forest is in mature and old-growth successional stages. The lower North Fork basin was logged many decades ago, and is now mostly relatively mature second growth.

Skokomish Valley

The Skokomish Valley has been extensively converted to agriculture through the cutting and removal of the aboriginal riparian forests. The U.S. Government Land Office (GLO) surveyor's field notes for the subdivision of the Skokomish Valley into townships and sections during the summer of 1861 indicate a floodplain forest, swampy and impassable in places, cut by numerous sloughs that drained the valley into the river. The witness trees to the section and quarter-section corners are indicative of a frequently inundated floodplain: vine maples, 4- to 8-inch diameter; alders, 6- to 20-inch; crabapples, 5- to 16-inch; willows, 6- to 84-inch; cedars 30- to 36-inch; maples, 18- to 36-inch; and an occasional dogwood, hazel, and hardhack. The frequency with which a short-lived species such as vine maple was selected as a witness tree to the section corners indicates a valley floor with abundant, dense brush and relatively few trees.

Today, most of the valley has been converted to pasture and Christmas tree plantations. The remaining riparian forests are mostly younger, second-growth stands on gravel bars, low-lying areas, and less desirable soils.

Skokomish Estuary

An ecological and resource characterization of the Skokomish Estuary was developed by Canning and Shea (1979) as follows. The salt marshes at the mouths of the Skokomish River are mapped as a "major salt marsh" of Hood Canal (Martinson 1976). The intertidal mud flats of the Skokomish delta cover at least 1,500 acres on the east side of Annas Bay, constituting one of the largest intertidal flats on Hood Canal. Annas Bay is classified as a major waterfowl area and supports large beds of eelgrass (Division of Marine Land Management 1977). The Skokomish delta contains the largest single Harbor Seal haul-out site in Puget Sound. The peak seal count, in 1977, was 342 adults and pups, 5 percent of the Washington state population and 15 percent of the Puget Sound population (Calambokidis et al. 1978). The Annas Bay-Skokomish Estuary system has been recommended for preservation as a wetland of particular significance (Yoshinaka and Ellifret 1974).

Historical changes in the character and extent of the Skokomish delta between 1884 and the late 1970s were studied by Bortleson et al. (1980). They noted minor changes in the shoreline near the mouths of the river where some shorelines had eroded (recession) and some had built up (progradation), with the shifts about equal. They also noted that the delta intertidal mud flats in Annas Bay had decreased by about 0.2 square mile.

A compilation of recent analyses relating to the Skokomish Estuary was completed as part of the Draft EIS for the Cushman Hydroelectric Project. A copy of the section relating to the estuary is included with this report as Appendix F.

Fisheries

The following discussion of fisheries is taken from the Preliminary Draft Skokomish River CFCMP (Ecology 1988). A more recent discussion of fisheries was completed as part of the Draft EIS for the Cushman Hydroelectric Project. A copy of the section relating to fisheries is included with this report as Appendix G. In addition, a fisheries inventory completed for the 1993 Draft CFHMP is included with this report as Appendix H.

The most complete and accurate source of information on the salmon fishery resource of the Skokomish basin is still the stream catalog of the Washington Department of Fisheries (WDF; now WDFW) (Williams et al. 1975) (Johnson, W., WDF, personal communication). Relatively little is known about the resident (non-anadromous) fish of the basin. The principal fisheries issues are water quality (e.g., dissolved oxygen, temperature), instream habitat (e.g., gravel quality, riffle-pool patterns), and streamside habitat (e.g., canopy coverage, shading, and buffers).

Anadromous Fish

Anadromous fish from the Skokomish River system and its tributaries support important commercial and recreational fisheries in Hood Canal, the Strait of Juan de Fuca, and the river itself. The Skokomish River system formerly produced substantially larger runs of salmon than it has in recent years (CH2M Hill 1983; Findlay 1973; Williams et al. 1975). Cushman Dam greatly reduced the anadromous fish habitat on the North Fork system by creating a barrier to historical spawning grounds and degrading habitat below the dam by diverting flows (Wampler 1980). The project developer, Tacoma City Light, has partially mitigated the fish loss by constructing the George Adams Fish Hatchery on Purdy Creek (Rushton 1985), operated by WDFW. This report concentrates on the fisheries of the primary study area, the Skokomish Valley.

Within the primary study area, the mainstem, lower South Fork, and Vance Creek provide spawning and rearing habitat for chinook, chum, coho, pink, and sockeye salmon, and steelhead and cutthroat trout; this portion of the basin is particularly important to chinook, coho, and chum production. A small upriver run of spring chinook passes through the Skokomish Valley, and matures in the deeper pools of the canyon reach of the South Fork during summer months. The major Skokomish run of fall chinook enters the river in September and October and spawns in the mainstem, the South Fork, and occasionally Vance Creek. All accessible tributaries contribute to coho production. Chum salmon spawning occurs in the mainstem and the tributaries, and is heaviest in Richert Springs, Vance Creek, and Swift Creek. Typical spawning populations in the early 1970s were 600 chinook and 1,800 chum (Williams et al. 1975).

In recent years, the South Fork spawning populations have been about 100 chum, 100 coho, 500 fall chinook, 60 spring chinook, and a few hundred winter steelhead and some summer steelhead. The South Fork tributary, Vance Creek spawning populations have been about 1,100 chum and 500 coho. The pink salmon run has essentially disappeared from the South Fork, apparently as a result of the large chinook and coho releases from George Adams Hatchery on the lower mainstem. The larger chinook and coho juveniles are thought to feed heavily on the migrating pink fry (Caldwell 1984).

North Fork spawning populations have been about 3,500 chum, 2,200 coho, 25 fall chinook, and some steelhead (Caldwell 1984).

Mainstem spawning populations have been about 250 chum, 500 coho, 800 fall chinook, and a few hundred winter steelhead and some summer steelhead (Caldwell 1984).

Limiting factors in the primary study area include low summer flows, which limit the availability of rearing areas, and excessively high winter flows, which intensify the problems associated with unstable streambed gravels (Williams et al. 1975). In addition, recreational misuse of the river is a localized problem where recreational vehicle (RV) operators drive in and through the river, damaging salmon eggs in the gravel. Fisheries and game enforcement agents report frequent motorized travel on the riverbed across salmon spawning redds, which can compact the gravel and grind the salmon eggs within the gravel.

The instability of the gravel bed of the river, the shifting pattern of the riverbed, and riverbed aggradation produce annual changes in spawning gravel locations. As a result, the locations of prime spawning gravels are not documented.

The production of the George Adams Hatchery on Purdy Creek, a tributary to the mainstem, is released principally into Purdy Creek, and also into other streams in Mason, Thurston, Kitsap, and Jefferson counties (see Table 2-4) (Abrahamson 1986).

TABLE 2-4.
SALMON RELEASES FROM GEORGE ADAMS HATCHERY, PURDY CREEK, SKOKOMISH BASIN, WASHINGTON, 1982-1986

	Salmon Species			
Year	Fall Chinook	Coho	Chum	Total
1982	2,541,697	2,170,365	-	4,712,062
1983	3,161,200	2,260,874	16,847,700	22,269,774
1984	3,704,600	614,400	7,967,000	12,286,000
1985	4,703,400	915,900	24,772,300	30,391,600
1986		Data not yet published.		

SOURCES: Abrahamson 1986; Castoldi 1983; Hill 1984; Kirby 1985.

Resident Fish

No substantive information is known about resident fish (e.g., rainbow trout, nonmigratory cutthroat trout, and nongame species) anywhere in the basin. This is not an unusual situation; resident fish are not the economic resource that anadromous fish are, and detailed studies are rarely carried out.

WDFW has operated the Shelton Trout Hatchery on Swift Creek at Mohrweis since 1946 (formerly as the Washington Department of Game). A variety of freshwater species are raised at the hatchery for release throughout western Washington. A small amount of the Shelton Trout Hatchery's production is released into the Skokomish River system.

Forecast

Salmon enhancement is proposed within the Skokomish basin under WDFW's Watershed Planning Program. Under the Hood Canal Salmon Management Plan, depleted spring chinook stocks would be rebuilt as the first step in the development of an overall strategy for fisheries management in the Skokomish basin. Other strategies proposed include the improvement of river flows, and the restoration and protection of spring chinook spawning and rearing habitats (WDOF 1987). The Point No Point Treaty Council, in conjunction with US-Canada Treaty studies, is conducting a Skokomish River Coho Indicator Stock Study. The Treaty Council also releases chinook salmon in the basin as a part of an enhancement program.

Flood control or management works could adversely affect fisheries habitat and production by impairment or destruction of spawning gravels and streamside vegetation. Questions remain about the effect of river aggradation on spawning gravel.

Wildlife

The following discussion of wildlife is taken from the Preliminary Draft Skokomish River CFCMP (Ecology 1988). A more recent discussion of wildlife was completed as part of the Draft EIS for the Cushman Hydroelectric Project. A copy of the section relating to wildlife is included with this report as Appendix I.

A characterization of the Skokomish basin's wildlife and habitats was developed during the late 1960s as a part of the PSAW Study (Fish and Wildlife Technical Committee 1970). The Skokomish basin was included with other east Olympic Peninsula basins and the Kitsap Peninsula basins as the West Sound Basins. Information on the Skokomish basin is summarized below. Due to the low level of development in the area, the description is probably still accurate.

Elk are found in medium-to-high population densities throughout the upper elevations of the South Fork basin and the mid elevations of the North Fork basin above Lake Cushman, and may be found throughout the entire basin except for the Skokomish Valley and the adjacent plateaus to the north. Deer are distributed throughout the basin, and concentrated in the area between the South and North Forks from the confluence north to Lake Cushman. Waterfowl are distributed throughout the eastern half of the basin, and particularly in the Skokomish Valley, which was identified as an important wintering area.

No wildlife population or habitat studies are known to have been conducted in the Skokomish Valley. Most native habitat has been converted to farm fields, and in recent years to Christmas tree plantations; these agricultural land uses have relatively little wildlife habitat value. The remnant riparian forests and forested wetlands of the Valley probably provide habitat for deer; small terrestrial mammals such as raccoon, chipmunks, mountain beaver*, mice, and voles; and aquatic mammals such as muskrat, beaver*, and river otter.

Seasonally, the forests provide habitat for migrating and nesting songbirds. The ponds and drainages of the valley provide wintering habitat for waterfowl such as mallard* and other dabbling ducks, and diving ducks such as bufflehead*. Resident species such as the great blue heron* can be expected to be locally common; during the late winter, bald eagles* commonly feed along the river from perches in riverbank trees. Farm fields provide habitat for starling*,

blackbirds*, and crow*. (Sightings have been made or evidence found of those species marked with an asterisk.)

Flood control or management works could adversely affect wildlife habitat and production by impairment or destruction of streamside vegetation.

Special Plants, Animals, and Ecological Communities

The following discussion of special plants, animals, and ecological communities is taken from the Preliminary Draft Skokomish River CFCMP (Ecology 1988). A more recent discussion of this topic was completed as part of the Draft EIS for the Cushman Hydroelectric Project. A copy of the section relating to Special Plants, Animals, and Ecological Communities is included with Appendix I.

Endangered, threatened, and sensitive plant and animal species, and high quality native plant (ecological) communities may be found throughout the Skokomish basin. This section addresses only the primary study area, the Skokomish Valley. Known special plants, animals, and ecological communities are summarized in Table 2-5 from information provided by the Natural Heritage Data System, operated by the Washington Natural Heritage Program (DNR) and the Nongame Wildlife Program (WDWF). To protect these rare resources from vandalism, the exact locations are not identified. The listing of special plants, animals, and ecological communities should not be considered complete, as it is based on fortuitous discoveries, not on a comprehensive survey of the valley.

TABLE 2-5.
KNOWN SIGHTINGS OF SPECIAL PLANTS AND ANIMALS

Element Name	Status	Location and Notes
PLANT SPECIES		
Woodwardia fimbriata Chain-fern	Proposed State Sensitive	Known from two streamside locales: near the river's mouth and on the mainstem.
ANIMAL SPECIES		
H. leucocephalus Bald Eagle	Federal and State Threatened	Breeding at two streamside locales: at the river's mouth and the confluence of the forks.
Martes pennanti Fisher	Proposed State Sensitive	Known from one location near Purdy Creek
COMMUNITY TYPES		
None yet reported within the Skokomish Valley.		

SOURCE: Natural Heritage Data System.

Flood control or management works could adversely affect the habitat and production of special species by impairment or destruction of streamside vegetation.

SOCIOECONOMIC CHARACTERISTICS

The social and economic systems of the Skokomish Valley are subsets of the larger systems operating throughout the Puget Sound region. Of predominate local importance are the

Skokomish Indian community at the mouth of the valley and the agricultural community in the main portion of the Valley. Notable outside influences are the regional economy and programs of local, state, and federal agencies.

The following discussion of socioeconomic characteristics is taken from the Preliminary Draft Skokomish River CFCMP (Ecology 1988). A more recent discussion of regional socioeconomic characteristics was completed as part of the Draft EIS for the Cushman Hydroelectric Project. A copy of the section relating to socioeconomic characteristics is included with this report as Appendix J.

Political Subdivisions

The Skokomish basin overlies three federal reserves, the Olympic National Park, the Olympic National Forest, and the Skokomish Indian Reservation; three counties, Mason, Grays Harbor, and Jefferson; and a number of special districts.

Olympic National Park

The Olympic National Park (ONP) has jurisdiction over most of the North Fork basin above the inlet to Lake Cushman. National Park lands are managed for preservation of natural habitat and low intensity recreation. The only National Park facility and station in this portion of the park is at Staircase Campground a few miles above the inlet to Lake Cushman.

Olympic National Forest

The Olympic National Forest (ONF) has jurisdiction over most of the South Fork basin and a small portion of the North Fork Basin. National Forests are managed primarily for timber production, and secondarily for other uses, such as minerals, grazing, and recreation. With the exception of Brown Creek Campground and the Skokomish River Trail from Brown Creek Campground to the ONP, the South Fork basin under ONF jurisdiction is managed for intensive timber production. This portion of the basin and the National Forest has an unusually high density of logging roads.

Skokomish Indian Reservation

The Skokomish Indian Reservation covers about 7.5 square miles north of the mainstem near the mouth of the river. About half the reservation lies in the floodplain, with an elevation of less than 40 feet (Molenaar and Cummans 1973).

The Skokomish Indian Tribe has jurisdiction over tribal and individual trust lands within the Reservation boundaries. However, substantial portions of the reservation have been lost to tribal ownership through alienation of privately owned land and condemnation for public purposes such as Tacoma City Light's powerhouse facility. Mason County can assert land use regulatory authority over alienated lands within the Reservation.

The Tribe has no formal, institutionalized land use planning or regulatory programs, including floodplain management or zoning.

County Government

The bulk of the Skokomish basin lies within Mason County. Fringes of the headwaters of the South Fork basin are within Grays Harbor and Jefferson Counties, and the headwater tributaries of the North Fork are within Jefferson County. These headwater areas are also wholly within the Olympic National Park and Olympic National Forest. The area of interest within the basin, the Skokomish Valley of the South Fork and the mainstem, lies wholly within Mason County. For purposes of this plan, therefore, the only local government involved is Mason County. The principal Mason County regulatory programs affecting the Skokomish Valley are the Shoreline Master Program (under the state Shoreline Management Act) and the Flood Damage Prevention Ordinance (under the National Flood Insurance Program). These regulatory programs are addressed in Chapter 5.

Drainage District

No drainage district has been established in the Skokomish Valley.

Flood Control District

The Skokomish Flood Control Zone District (FCZD) was established in 1976 under the authority of the Flood Control Zone Districts Act (Chapter 86.15 RCW). The formation of a flood control district was considered necessary and desirable for the elimination of piece-meal flood control projects often found to be inconsistent with resource management regulatory programs, and to ensure that coordination of future flood control works included proper application and review procedures. The district boundaries were established as the Skokomish River watershed, less those portions lying within Grays Harbor and Jefferson Counties, Olympic National Park, Olympic National Forest, and the Skokomish Indian Reservation.

Flood Control Zone Districts may be established for the purpose of "undertaking, operating, or maintaining flood control projects or storm water control projects or groups of projects that are of special benefit to specified areas of the county" (RCW 86.15.020). A five-member Advisory Committee (FCZDAC) composed of Skokomish Valley residents was appointed by the Mason County Commissioners in accordance with RCW 86.15.070. As quasi-municipal corporations, FCZDs have taxing authority; the Skokomish FCZD taxes property within the district at $0.50 per $1,000 assessed valuation.

The District's Flood Control Plan identifies the following three action priorities:

- Develop a program to protect or restore all existing flood control facilities
- Increase the water flow capacity of the mainstream channels
- Construct and maintain new dikes and barriers in locations that will reduce flood hazards

The following four specific work projects are also identified:

- Clean the channel and bank at the US 101 bridge (including the gravel island one-third mile upriver)

- Remove debris in selected areas, e.g., the old Crossman place
- Stabilize the river bank, e.g., at the church
- Eliminate point sources where gravel is entering the river system, e.g., the bluff below McKay Flats.

In the past, funds raised by the District have been used to finance minor instream gravel removal, instream earth-moving, and streamside dike construction. Few of these projects have been substantial enough to resist subsequent destruction or deterioration by flood waters.

Soil and Water Conservation District

Mason County is served by a Soil and Water Conservation District which is currently inactive. Staff support is provided by the Thurston County district, with offices in Olympia.

Population and Housing

The population of Mason County grew at an annual rate of about 5 percent from 1974 to 1982 (Mason Regional Planning Council 1982). Since then, the average annual growth rate has decreased to little more than 2 percent, as shown in Table 2-6. From 1980 to 1986, deaths (1674) exceeded births (1320); the net increase (2542) is therefore due to migration (2896).

TABLE 2-6.
MASON COUNTY POPULATION (1980 - 1986) AND FORECAST (1990 - 2000)

Year	Unincorporated. Areas	Shelton	Total	Average Annual Growth Rate, %	Total Employment
1980	23,555	7,629	31,184		10,180
1981	24,300	7,600	31,900		9,750
1982	24,960	7,740	32,700		9,370
1983	26,000	7,600	33,600	2.14%	10,750
1984	27,200	7,600	34,800		10,940
1985	27,250	7,550	34,800		11,300
1986	27,850	7,550	35,400		11,590
1990			38,156		
				1.99%	
1995			42,099		
				2.16%	
2000			46,840		

SOURCE: Office of Financial Management, 1986:5, 57 (population data);
US Department of Labor, Bureau of Labor Statistics (employment data).

By comparison, during the 1980-1986 period, when Mason County population increased by 13.52 percent, Washington State population growth was 6.95 percent, while adjacent counties experienced the following growth: Thurston, 14.43 percent; Kitsap, 11.79 percent; Grays Harbor, -5.00 percent (OFM 1986:29).

Mason County population growth is typically attributed to spillover from Kitsap and Thurston Counties. If this were true, population growth should exceed employment growth. However, from 1980 to 1986, when Mason County population growth averaged 2.14 percent annually, employment growth averaged 2.19 percent annually, despite a slump during the 1981-1982 recession. This indicates population growth attributable to internal, not external, factors. It is likely, however, that Mason County's population and employment growth is influenced by growth in the Port Orchard and Olympia areas of Kitsap and Thurston counties.

The population data include only permanent residents. Many owners of second homes also live in the county for much of the year and place a demand on certain public services. This is particularly true of the communities and developments along Hood Canal, but is not thought to be significant in the Skokomish Valley. Many second homes are becoming permanent residences as their owners retire to Mason County.

Economic Sectors

The economy of the Skokomish basin is based on its natural resources; the principal economic sectors are timber and tourism. The timber industry relies on the public and private commercial forests. In the past, intensive timber harvest in the Shelton CSYU yielded a high number of woods and mill jobs; most of this employment was held by people residing outside the Skokomish basin in Mason and Grays Harbor counties. The tourism and hospitality industry relies on the forest preserves of the Olympic National Park and on the attraction of Hood Canal. Secondary economic sectors include shellfisheries in Hood Canal, service businesses (e.g., restaurants and diners), retail sales (e.g., convenience stores, gas stations, and fireworks stands), and government employment (e.g., fish hatcheries and Tribal government).

The economy of the Skokomish Valley is based on agriculture. Dairy farming was once the predominant business and land use in the valley. Dairying began to decline in the 1950s, and by the 1980s had disappeared from the Valley. In recent years, Christmas tree farming has become popular here, as elsewhere in Mason County. Some former dairy farms are now operated for cattle production, but many farm operators, having abandoned dairying, have not yet converted to another form of agriculture, and their fields lie idle.

Land Use

Most of the basin is forested, either as forest preserves in the Olympic National Park, or as managed timber forests in the Olympic National Forest or on industrial timber lands. Only in the Skokomish Valley of the South Fork and the mainstem, and to a lesser degree along the southeastern shores of Lake Cushman, are other land uses found. Land use within the basin is summarized in Table 2-7, and land ownership in Table 2-8. Land ownership is shown in Figure 2-7.

General land use in the Skokomish Valley can generally be characterized as rural-residential and agricultural. Residences are scattered about in the valley, with a small concentration in the area of Mohrweis near the confluence of the North and South Forks.

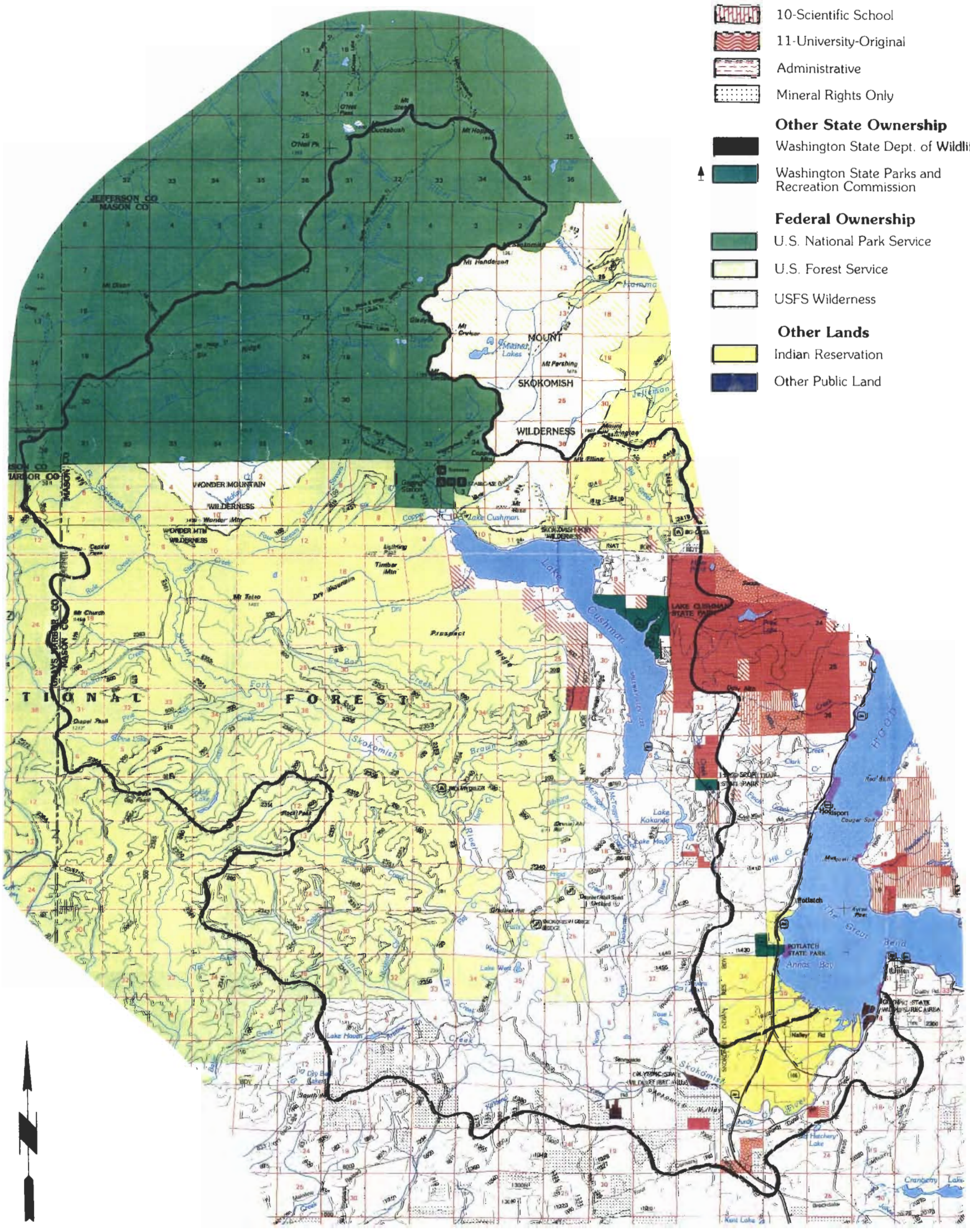

LAND OWNERSHIP
DNR Managed Lands
01-State Forest Board-Transfer
02-State Forest Board-Purchased
03-Common School, Indemnity and 09-Escheat
none
04-Agricultural School
05-University-Transferred
06-Charitable, Educational, Penal and Reformatory Institutions
07-Capitol Building
none
08-Normal School
10-Scientific School
11-University-Original
Administrative
Mineral Rights Only
Other State Ownership
Washington State Dept. of Wildlife
Washington State Parks and Recreation Commission
Federal Ownership
U.S. National Park Service
U.S. Forest Service
USFS Wilderness
Other Lands
Indian Reservation
Other Public Land
JEFFERSON CO
MASON CO
MOUNT
SKOKOMISH
WILDERNESS
WONDER MOUNTAIN
WILDERNESS
Lake Cushman
Lake Kokanee
Hoodsport
Potlatch
POTLATCH STATE PARK
Union
Annas Bay
Skokomish
Prospect
Timber Mtn
Mt Telso
Dry Mountain
Mt Church
Mt Henderson
Mt Pershing
Mt Ellinor
Mt Cruiser
Mt Steel
Mt Hopper
Ductabush
O'Neil Pk
Cedar Pass
Lake Hoven
Lake Wee
Dry Bed Lake
Hatchery Lake
Cranberry Lake
Kent Lake
Hamma
Jeffersonville
Mason Lake
Cougar Spit
Hood Canal
The Great Bend
Skokomish River
Lake Cushman State Park
Hood Sport Trail State Park
Olympic State Wilderness Rec Area
Union State Wilderness Rec Area
Nalley Rd
Cushman Rd
Skokomish Valley Rd
Cushman Rd
Dayton Rd
Cemetery Rd
Kamilche Rd
Cranberry Rd
Brockdale Rd
Mason Lake Rd
Hill Cr
Clark Cr
Jackson Cr
Jeffersonville Rd
Lake Hoven Rd
Lake Wee Rd
Dry Bed Lake Rd
Hatchery Lake

TABLE 2-7.
SKOKOMISH BASIN LAND USE

Land Use Classification	Acres	Percent of Basin
Agriculture	3,058	2
Farm Woodland	32,751	20
Forest Land [a]	100,720	61
Range Land	660	1
Miscellaneous	26,811	16
TOTAL	164,000	100

a. Includes Olympic National Forest and other public lands.

SOURCE: Cowley, 1958

TABLE 2-8.
SKOKOMISH BASIN LAND OWNERSHIP

Land Ownership	Acres	Percent of Basin
National Forest	78,500	48
National Park	30,000	18
Washington State	4,500	3
City of Tacoma	10,000	6
Skokomish Indian Tribe	3,000	2
Private	38,000	23
TOTAL	164,000	100

SOURCE: Cowley, 1958.

Public Services and Utilities

Sewage Disposal

No sewer facilities serve the Skokomish Valley. Sewage treatment and disposal is through individual septic systems and leaching fields. The soils of the Skokomish Valley are mostly alluvium, and the water table varies seasonally, from a few feet below the surface during the summer, to at or near the surface during the winter. These conditions place severe restrictions on residential development using conventional onsite sewage disposal methods. Seasonally high water tables can inundate septic tanks and saturate leach fields, and the leachate can contaminate aquifers tapped by shallow domestic wells (Foxworthy 1975); see also Table 2-3.

Hydropower

Tacoma City Light operates two related hydropower facilities on the North Fork, Cushman Reservoir (Cushman I powerplant) and Lower Cushman Reservoir (Cushman II powerplant). The two power plants produce 131 MW, about 15 percent of Tacoma's total owned resource of 868 MW. Annually, the facilities provide Tacoma with about 343 Gwh, about 4 percent of its total energy requirements. The Cushman facilities were licensed by the Federal Power Commission (now the FERC) as single-purpose hydropower facilities. Additional details of the history and operation of the Cushman Hydroelectric Project are presented in Appendix K.

In the early 1980s, Public Utilities District No. 3 of Mason County (PUD 3) conducted feasibility studies of three large hydropower developments on the South Fork. A Draft Environmental Impact Statement (DEIS) was issued in February 1983. The proposal is currently dormant. The project would have included a 292-foot-high dam on the South Fork at RM 9.1, creating a 6-mile-long reservoir. The project would have modified flows in the lower South Fork and the mainstem by augmenting low flows and reducing high flows. Annual floods in the Skokomish Valley would have been reduced in size and frequency due to the proposed reservoir's minimum 25,000 acre-foot flood storage capacity. Flood flows of up to the 10-year recurrence interval could have been contained by this storage capacity. More severe flood flows could have been mitigated, but not wholly contained. Large floods (e.g., the 100-year event) could not have been contained, and the extent of the floodplain of the Skokomish Valley would not have been reduced (CH2M Hill 1983). The reservoir would also have contained the sediments and bedload currently being transported from the upper South Fork into the lower South Fork and the mainstem.

Transportation

The transportation network in the primary study area is shown on Figure 2-5. Access to points north is via US 101 to Port Townsend and thence by ferry to Whidbey Island, and to Port Angeles and thence by ferry to Vancouver Island. Access to points east is via SR 106 and SR 3 to Bremerton and thence by ferry to Seattle and Interstate 5. Access to the south is via US 101 to Olympia and I-5. Limited access to the west is provided by Olympic National Forest roads.

The transportation system of the Skokomish Valley is unusual for a Pacific Northwest river valley. Historically, trails and early roadways were built along the borders of the valleys in because the valley bottoms were inundated every winter (Sedell and Luchessa 1982). This practice is exemplified in the lower Skokomish Valley by the alignment of Purdy Cut-Off Road (Road 4178) and a portion of SR 106, which are at the base of the slopes on the southeast side of the valley. In contrast, Skokomish Valley Road (Road 4164) and Bourgault Road West (Road 4196) were constructed largely along public land survey lines on the valley floor, crossing many side channels of the original river system. As a result of their poor location, these roads are frequently flooded. This issue is discussed in Chapter 5.

US 101 was constructed across the Skokomish Valley on fill to protect the roadway from frequent inundation during winter high flow periods. The highway bridges the mainstem and a secondary channel approximately 1,000 feet north. The highway elevation is nevertheless insufficient to prevent occasional flooding of the roadway. The highway fill also acts as a dam, lessening the flooding of some downstream properties on the south side of the river, and contributing to the frequency, severity, and duration of flooding of some upstream properties. This effect is discussed in Chapter 6.

SR 106 was also constructed on fill across the Skokomish Valley, but at a lower elevation than US 101. The Bureau of Indian Affairs (BIA) is currently investigating alternatives for rebuilding and raising the elevation of SR 106 for the Skokomish Indian Tribe.

Mason County does not operate a public transit system, and no local public transportation routes serve the Skokomish Valley.

Recreation

Recreation in the Skokomish basin is focused on hunting and fishing, hiking and camping, and water sports. The Olympic National Park and Olympic National Forest maintain trail systems out of the USFS Brown Creek Campground on the South Fork and from the road heads along Lake Cushman and the North Fork. The State Parks and Recreation Commission maintains a campground and the City of Tacoma provides a boat launch facility at Lake Cushman.

The only established public recreation facility in the primary study area is a WDFW fishing access on the left bank of the mainstem in Section 8, T21N, R4W, near RM 6.7 (Hutchison 1976), which also provides a rough boat launch (an unimproved launch area that can be used by small trailered boats). There is also an informal fishing access to the right bank of the South Fork approximately one-half mile west of Mohrweis (RM 0.5), from which it is possible to launch car-top-carried boats.

The two major highways that cross the Skokomish Valley, US 101 and SR 106, are Designated State Scenic Highways (Hutchison 1976).

The overall river recreation values of three segments of the Skokomish system were determined in the Pacific Northwest Rivers Study of the Northwest Power Planning Council (NPPC) and Bonneville Power Administration (BPA). An upper segment of the South Fork, from the headwaters area in Olympic National Park to the Pine Creek confluence (RM 19.2) in Olympic National Forest, is rated A (high recreation value) overall, A for its camping and picnicking, and hiking and backpacking values, and B (above average) for its wildlife viewing values. A middle segment, from Pine Creek to the Brown Creek confluence (RM 12.8) and USFS Brown Creek Campground, is rated B overall, B for its hiking and backpacking, and wildlife viewing values, and C (average) for its camping and picnicking values. A lower segment, from Brown Creek to the river's mouth on Hood Canal, is rated C overall, B for its flatwater boating values, and C for its whitewater kayaking values (Anderson et al. 1986).

The value of the river for boating (e.g., canoeing, kayaking, rafting) is reduced by the danger of log jams and sweepers (logs protruding over the river from the banks). In addition, the (illegal) practice of riprapping the river banks with automobile bodies endangers boaters, who might be swept by the river current into an automobile body and drowned.

Cultural Resources

Cultural resources in the study area were documented in the USFS Watershed Analysis and the Draft EIS for the Cushman Hydroelectric Project. Sections of these documents relating to cultural resources are included with this report as Appendix L and Appendix M.

CHAPTER 3.
HYDROLOGY OF THE SKOKOMISH VALLEY

Changes to one component of the hydrologic cycle can, and often do, have a large effect on other components. For example, stream flow is dependent on precipitation its disposition as rain or snow, and its effect on snowmelt. If a significant snowpack is present during a heavy, warm rain, extreme flow events can, and typically do, occur. A comprehensive understanding of the hydrology of the valley and the watershed is critical to developing flood hazard management approaches.

INTRODUCTION

Part of the rain falling on the landscape is intercepted by vegetation; most of this evaporates. Rainfall on impervious surfaces contributes to storm runoff, though small amounts will evaporate. In urban areas, impervious surfaces include pavement, buildings, and compacted soil. In natural areas, other surfaces may function as impervious in that they contribute runoff directly. These areas include wetlands, shallow soils that become saturated early in the winter rainy season, and rock outcroppings.

Of the remaining rainfall, a portion infiltrates the ground and a portion runs off immediately. In the Skokomish basin, the permeability of most soils exceeds most rainfall intensities, so there is little immediate surface runoff from most areas. Of the rain that infiltrates the soil, a portion is taken up by the plants. Plants will then use some of the water and transport the remainder back to the atmosphere through a process called transpiration. The remainder moves slowly through the groundwater into deeper aquifers, or through near-surface aquifers to emerge later at lower elevations as *delayed-runoff* or *interflow*.

Surface runoff, and to a lesser degree groundwater, carries with it a load of suspended and dissolved solids. Therefore, the drainage process is also a process of erosion. The rates of erosion can be slow and imperceptible, as in rain splash erosion; moderate, as in sheet, rill, and gully erosion; or catastrophic, as in landsliding (see Figure 3-1). Once deposited in a stream, sediments move downstream continuously as a part of the suspended sediment load, or periodically as a part of the bedload rolled along the bottom by higher flow velocities.

River geomorphology models portray river zones as proceeding from a head waters of *fixed zone* through *braided* and *meandered zones* to an estuarine delta (see Table 3-1). In nature, the zones are not clearly distinguishable and are usually in a mixed and repetitive order because river gradients do not uniformly decrease from headwaters to mouth.

The fixed (boulder) zone often coincides with V-shaped canyons, steep terrain, and high erosion rates. The braided zone is often associated with U-shaped valleys and fixed zone tributaries. Braided river reaches are usually dynamic, shifting systems that occur where river energy has decreased due to decreased gradient or diverted flow, or to an increase in sediment supply. The meander zone is usually associated with broad lowland floodplains. Meander patterns migrate downstream as the leading edge of a meander erodes its bank while the following edge of the meander is depositional. For this reason, modern floodplain management practices often include a prohibition of any substantial construction in the meander belt, a corridor bounded by the outer extremes of meandering. Deltaic zones are usually associated with the estuarine mouths of rivers,

but may also be found at the inlets to lakes and reservoirs where substantial sedimentation occurs. Some geohydrologists consider the deltaic zone to be a specialized form of the braided zone.

TABLE 3-1.
RIVER GRADIENT, MORPHOLOGY, AND BED MATERIAL MODEL

Channel Character	Channel Gradient	Bed Material	Material Budget	Comments
Fixed	25 ft/mi	Cobbles to boulders	Eroding to neutral	Usually found as a headwaters reach
Braided	5 to 25 ft/mi	Sand to gravel	Accretional to neutral	Usually found as a mid-elevation reach, but may occur at lower elevations
Meandered	0 to 5 ft/mi	Silt to sand	Usually accretional	Usually found as a lowlands reach
Deltaic	0 ft/mi	Clay to silt	Accretional	Typically an estuarine delta but may occur at lake and reservoir inlets

Source: Adapted from Proctor, et al., 1980:I, Figure 2-3.

The relationship between watershed hydrology and river geomorphology will be discussed in detail in the following sections. Specifically, the occurrence of aggrading reaches of river, or sections of river where sediment deposition is raising the elevation of the bottom of the river, will be discussed in the context of the overall watershed hydrology and geomorphology.

SURFACE WATER HYDROLOGY

The hydrology of the Skokomish Basin is controlled by the system of natural and constructed conveyance features that move water from the mountains to the delta. Statistics such as mean monthly flows are calculated from data collected at gauging stations throughout the basin to characterize surface water quantities. Surface water quality is measured through collection and analysis of samples. Analytical results are then compared with regulatory standards to determine the health of the system.

System Description

The Skokomish River system was described in general terms in Chapter 2. In both a flood hazard management context and a water resources context, it is most useful to subdivide the Skokomish basin into the North Fork subbasin above Tacoma City Light's Cushman facilities, the South Fork sub-basin above the confluence of the North and South Forks, and the Skokomish Valley, primarily the mainstem and the associated subbasin.

Differences in watershed hydrology in the North and South Fork subbasins have their origins in the differences in types of resource development in each subbasin. In turn, these differences affect the hydrology of the mainstem subbasin below the forks. For example, the Cushman Hydroelectric Project has had a dramatic effect on flood frequencies and the duration of flows of certain frequencies in the mainstem.

Prior to construction of the Cushman Hydroelectric Project, the South Fork subbasin contributed approximately twelve percent more flow to the mainstem Skokomish than the North Fork, in spite of its slightly smaller area. This was because portions of the North Fork basin are in the rain shadow of the Olympic Mountains, while the South Fork basin is more exposed to Pacific storms.

Construction of the Cushman Hydroelectric Project altered the hydrologic conditions in the Skokomish Valley. Since 1930, Tacoma City Light has diverted virtually all the flow of the North Fork out of the basin directly to its powerhouse on Hood Canal. Only the South Fork makes substantial contributions to flows in the mainstem and the flooding problems of the Skokomish Valley. The Cushman Project diversions are diagrammed in Figure 3-1.

The South Fork Skokomish River has a drainage area of 104 square miles and an average annual flow of 9.79 cfs per square mile (based on USGS records from the gauging station near Union). The North Fork Skokomish River has a drainage area of 118 square miles. The average annual flow from the unregulated upper basin is 8.82 cfs per square mile and that from the regulated lower basin is 0.93 cfs per square mile (based on USGS records from the gauging stations near Potlatch and below Staircase Rapids). This means that 90 percent of the North Fork flow and 45 percent of the mainstem Skokomish flow is diverted by the Lake Cushman Project.

Hydrologic conditions in the Valley are affected by local drainageways. As mentioned in Chapter 2, land use in the Valley is predominantly agricultural with several small, family farms. Streams and drainage ditches are common along fields throughout the Valley. Flooding along these ditches and streams has been quite severe, in addition to the flooding along the river. During larger flood events, the hydraulic relationship between the valley streams and ditches and the river exacerbates flooding.

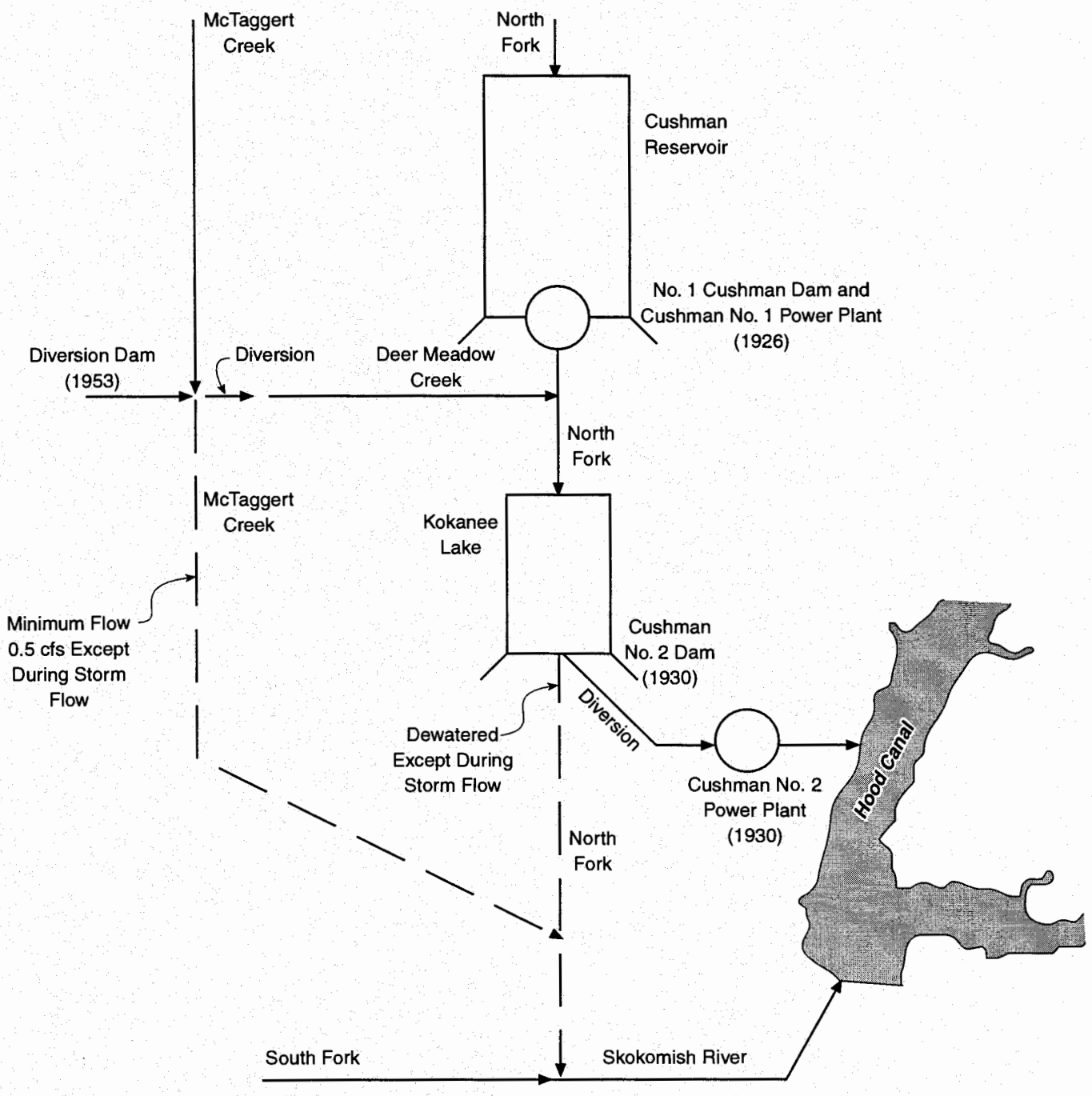
Flow Gauges

According to long-time residents, in recent years the valley has experienced more frequent and damaging floods. Documentation of all river flows is done through the use of flow gauges.

Eight gauging stations are located on the mainstem and the North and South Forks of the Skokomish River. The period of record for these gauges varies from a few years to many decades. Table 3-2 lists each gauge and its location and period of record. Gauging station locations are shown in Figure 3-2.

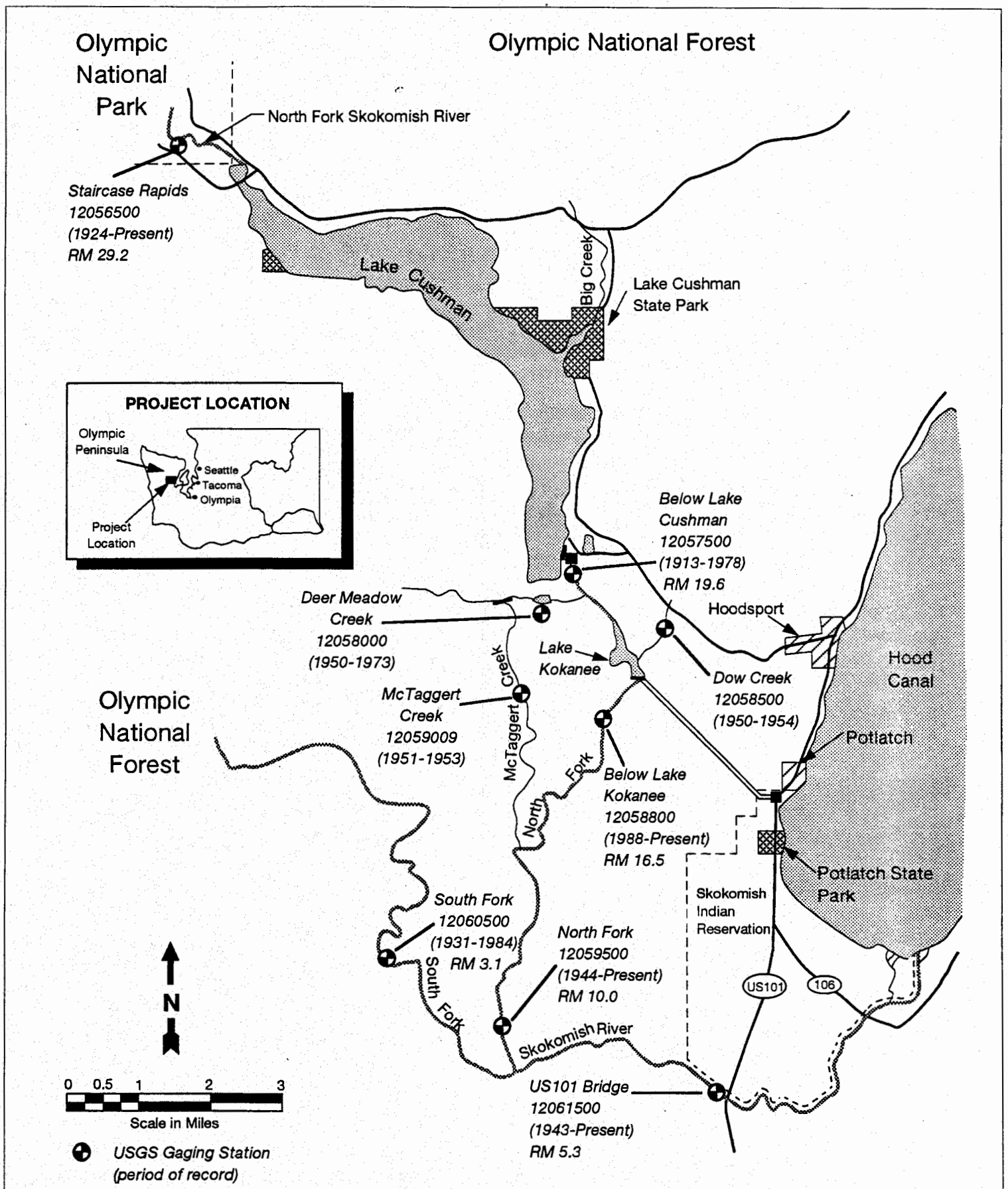
Mean Monthly Flows

Figure 3-3 shows the mean monthly flows for the Skokomish River gauging station near Potlatch. The majority of flow occurs in the winter months when rainfall is greater. This is generally true for all the gauging stations, although the flows entirely controlled by the Cushman Dam may vary slightly. For the Skokomish near the Potlatch station, 58 percent of the total average annual runoff occurs from November through February. Table 3-3 summarizes the mean monthly flows for all eight gauging stations.



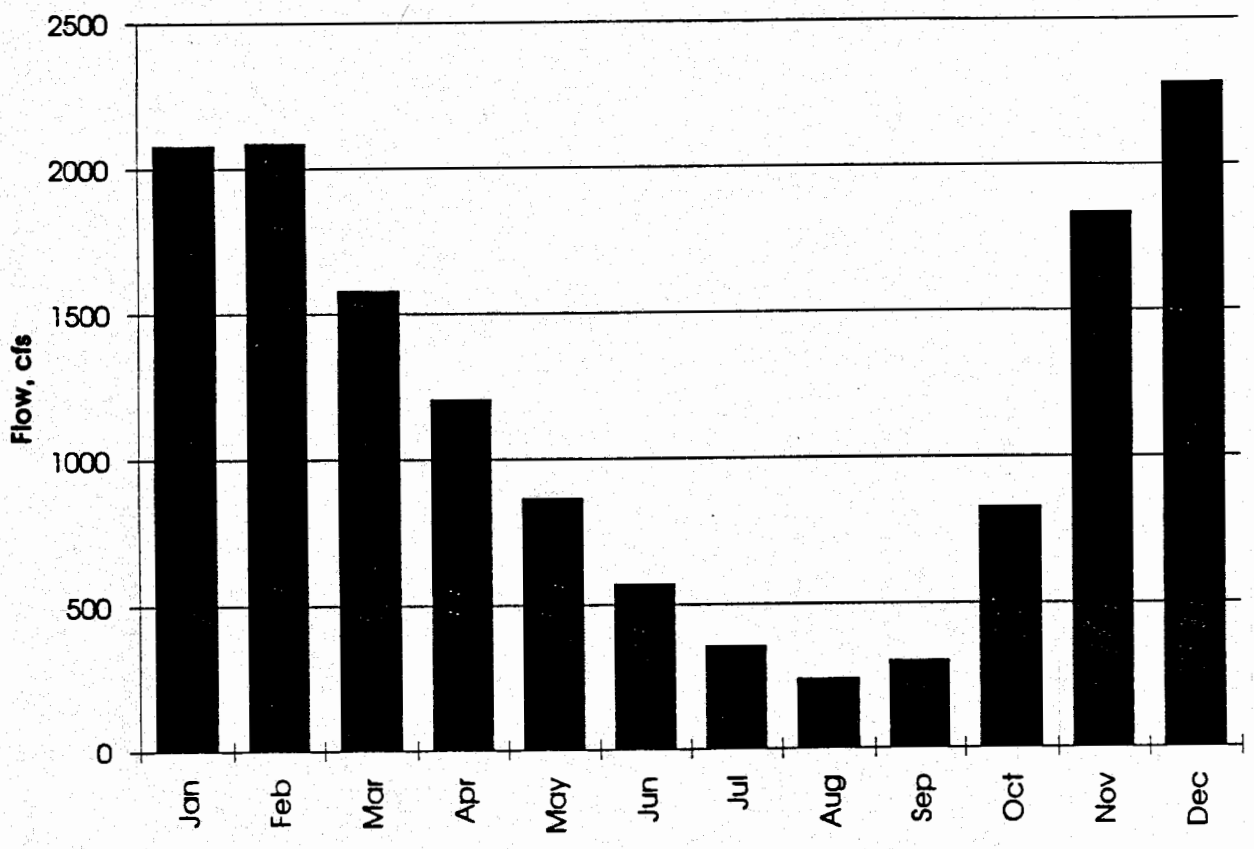
SOURCE: Ecology, 1988.

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 3-1. CUSHMAN PROJECT DIVERSIONS



SOURCE: Federal Energy Regulatory Commission, November 1995.

KCM 1917 First Avenue Seattle, Washington 98101	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 3-2. GAGING STATION LOCATIONS



KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 3-3. MEAN MONTHLY FLOW OF SKOKOMISH RIVER NEAR POTLATCH

TABLE 3-2.
SKOKOMISH RIVER GAUGING STATIONS

Description and ID number	Location	Period of Record
Mainstem Skokomish River near Potlatch 12061500	3.7 miles d/s of confluence of N. and S. forks	Jul. 1943 - Present
N. Fork Skokomish River near Potlatch 12059500	7.2 miles d/s of Lower Cushman Reservoir, 1.1 miles u/s of confluence with S. Fork	Mar. 1944 - Nov. 1949, Mar. 1950 - Present
N. Fork Skokomish River below Cushman Dam 12058800	1.2 miles downstream of Lower Cushman Reservoir	Jun. 1988 - Present
N. Fork Skokomish River near Hoodsport 12057500	on Upper Cushman Reservoir	Feb. 1913 - Sep. 1930, Oct. 1941 - Sep. 1978
N. Fork Skokomish River below Staircase Rapids 12056500	1.2 miles upstream of Upper Cushman Reservoir	Jul. 1924 - Present
S. Fork Skokomish River near Union 12060500	3.2 miles u/s of confluence with N. Fork	Aug. 1931 - Sep. 1984
S. Fork Skokomish River near Potlatch 12060000	1 mile u/s from Rock Creek	Oct. 1924 - Sep. 1932, Sep. 1946 - Sep. 1964
S. Fork Skokomish River near Hoodsport 12059800	100 feet d/s from Pine Creek	Oct. 1964 - Sep. 1970

Water Quality

The Skokomish River and its tributaries are classified as Class AA waters (WAC 173-201-080 [93]) for the establishment of water quality standards. Class AA water quality standards are summarized in Table 3-4.

In January 1980, Ecology established a water quality monitoring station (number 16A070) near the USGS stream gauge at RM 5.3 on the mainstem. The data from that monitoring station (available through October 1996) are presented in Appendix KK.

FLUVIAL GEOMORPHOLOGY

Fluvial geomorphology is the study of the linkage between a river's hydrologic characteristics and its geology and morphology, or form of the landscape. Whether a river is meandered or braided as it flows across a plain, or a deeply incised canyon is a function of the geology of the landscape, the volume of water carried, and the volume of sediment moved by the flowing water.

Geomorphologic changes in the primary study area, the Skokomish Valley, are of particular importance for two reasons: the streambank erosion and deposition associated with channel shifts and meander migration, and riverbed aggradation. In the 10,000 to 12,000 years since the retreat of the glacier from the Skokomish Valley, the mainstem has meandered across the entire valley floor. In the context of geologic time, the present location of the mainstem on the north side of the valley is temporary.

TABLE 3-3.
SKOKOMISH RIVER BASIN
SUMMARY OF MEAN MONTHLY FLOWS

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
North Fork Skokomish River below Staircase Rapids (1.2 miles upstream of Upper Cushman Reservoir)												
Period of Record: July 1924 to current year									Drainage Area: 57.2 sq mi			
Mean Monthly Flow (cfs)	662	627	484	505	664	612	346	155	147	373	701	781
% of Average Annual Flow	10.97	10.39	8.02	8.37	11.00	10.14	5.73	2.57	2.44	6.18	11.61	12.94
Flow per Unit Area (cfs/sq mi)	11.57	10.96	8.46	8.83	11.61	10.70	6.05	2.71	2.57	6.52	12.26	13.65
South Fork Skokomish River near Union (3.2 miles upstream of confluence with North Fork)												
Period of Record: August 1931 to September 1984									Drainage Area: 76.0 sq mi			
Mean Monthly Flow (cfs)	1314	1208	933	758	603	385	224	139	196	532	1143	1495
% of Average Annual Flow	14.80	13.60	10.51	8.54	6.79	4.34	2.52	1.57	2.21	5.99	12.87	16.84
Flow per Unit Area (cfs/sq mi)	17.29	15.89	12.28	9.97	7.93	5.07	2.95	1.83	2.58	7.00	15.04	19.67
South Fork Skokomish River near Potlatch (1 mile upstream from Rock Creek)												
Period of Record: October 1924 to September 1932, September 1946 to September 1964									Drainage Area: 65.6 sq mi			
Mean Monthly Flow (cfs)	1021	1073	675	665	539	349	188	120	151	518	932	1037
% of Average Annual Flow	14.13	14.85	9.34	9.21	7.46	4.83	2.60	1.66	2.09	7.17	12.90	14.35
Flow per Unit Area (cfs/sq mi)	15.56	16.36	10.29	10.14	8.22	5.32	2.87	1.83	2.30	7.90	14.21	15.81
South Fork Skokomish River near Hoodsport (100 feet downstream from Pine Creek)												
Period of Record: October 1964 to September 1970									Drainage Area: 26.0 sq mi			
Mean Monthly Flow (cfs)	511	393	330	307	300	242	110	68	105	303	431	303
% of Average Annual Flow	13.96	10.74	9.02	8.39	8.20	6.61	3.02	1.86	2.87	8.28	11.78	8.28
Flow per Unit Area (cfs/sq mi)	19.65	15.12	12.69	11.81	11.54	9.31	4.23	2.62	4.04	11.65	16.58	11.65

TABLE 3-3 (Continued)
SKOKOMISH RIVER BASIN
SUMMARY OF MEAN MONTHLY FLOWS

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Skokomish river near Potlatch (5.3 miles upstream of mouth, 3.7 miles downstream of confluence of North and South Forks)												
Period of Record: July 1943 to current year									Drainage Area[a]: 227 sq mi			
Mean Monthly Flow (cfs)	662	627	484	505	664	612	346	155	147	373	701	781
% of Average Annual Flow	10.97	10.39	8.02	8.37	11.00	10.14	5.73	2.57	2.44	6.18	11.61	12.94
Flow per Unit Area (cfs/sq mi)	11.57	10.96	8.46	8.83	11.61	10.70	6.05	2.71	2.57	6.52	12.26	13.65
North Fork Skokomish river near Potlatch (7.2 miles downstream of Lower Cushman Reservoir, 1.1 miles upstream of confluence with South Fork)												
Period of Record: March 1994 to November 1949, March 1950 to current year									Drainage Area[a]: 117 sq mi			
Mean Monthly Flow (cfs)	226	210	142	85	51	39	23	17	15	72	191	237
% of Average Annual Flow	17.60	16.36	11.06	6.62	3.97	3.04	1.79	1.32	1.17	5.61	14.88	18.46
Flow per Unit Area (cfs/sq mi)[b]												
North Fork Skokomish River below lower Cushman Dam (1.2 miles downstream of Lower Cushman Reservoir)												
Period of Record: June 1988 to current year									Drainage Area[a]: 102 sq mi			
Mean Monthly Flow (cfs)	36	35	36	33	31	29	31	31	52	35	37	50
% of Average Annual Flow	8.11	7.88	8.11	7.43	6.98	6.52	6.98	6.98	11.72	7.88	8.33	11.26
Flow per Unit Area (cfs/sq mi)[b]												
North Fork Skokomish River near Hoodsport (on upper Cushman Reservoir)												
Period of Record: February 1913 to September 1930, October 1941 to September 1978									Drainage Area: 93.7 sq mi			
Mean Monthly Flow (cfs)	1227	984	745	559	526	579	395	302	485	872	1153	1280
% of Average Annual Flow	13.53	10.85	8.21	6.16	5.80	6.38	4.35	3.33	5.35	9.61	12.71	14.11
Flow per Unit Area (cfs/sq mi)	13.10	10.50	7.95	5.97	5.61	6.18	4.22	3.22	5.18	9.31	12.31	13.66

Source: Earthinfo CD ROM database. The data presented are based on water years (October through September).
a. This area includes 99 square miles upstream from Lower Cushman Reservoir, which is non-contributing except during spillage.
b. Runoff rates were not calculated at this station since flow is regulated by the Cushman dams.

TABLE 3-4.
CLASS AA WATER QUALITY STANDARDS, WASHINGTON[a]

Parameter	Units	Standard
Fecal coliforms (FC)	Organisms/100 ml	Mean < 50;< 10% of samples > 100
Dissolved oxygen (DO)	mg/liter (parts per million)	> 9.5
Total dissolved gas	percent of saturation	< 110
Temperature	Degrees Celsius	< 16° [b]
Hydrogen ion	pH units	6.5 to 8.5
Turbidity	NTU units	< 5 over background[b]
Toxics	Not applicable	No effect on public health[b]
Aesthetics	Not applicable	No impairment[b]

a. Source: WAC 173-201-045 (1).
b. See WAC 173-201-045 (1) for details or special conditions.

During the past 120 years, gradual, cumulative shifts and migrations of the mainstem and lower North and South forks can be traced from mapping and aerial photographs. Figure 3-4 depicts river channel locations during the 1860s and 1870s, in the 1930s, and in the present.

The accuracy of this mapping is known to be faulty in some locations. The channel locations of the original mapping along the line between Townships 4 and 5 do not match. The configuration in Figure 3-4 was derived by adjusting contradictions to topographic conditions. In general, however, the pattern of the river depicted for the 1860s and 1870s is representative of that time, if not absolutely accurate.

During the 60 to 70 years up to the 1930s, the lower South Fork meanders shifted considerably with no apparent pattern. The lower North Fork changed to more pronounced meandering. The confluence of the forks migrated downstream approximately ¼ mile. From the confluence (RM 9) to the location of the old highway bridge (RM 6), the mainstem maintained its course in a general sense, with the meanders forming more intricate patterns, including the development of secondary channels. From the old bridge down to RM 4, substantial channel changes took place, and a second main channel formed south of the Section 15 meanders. The lower 4 miles of the river remained virtually unchanged.

Between the 1930s and the present, the lower South Fork continued to exhibit instability and major meander migration. The confluence shifted north slightly. From the confluence (RM 9) down to the location of the old highway bridge (RM 6), the mainstem meanders migrated slightly, and the secondary channels were abandoned by the river or filled by landowners. From the old bridge down to RM 4, abandonment and filling of the Section 15 meanders shifted all mainstem flow to the new channel. The lower 4 miles of the river remained virtually unchanged.

There have been no major channel shifts in the past seven or eight years, although bank erosion continues to cause cumulative changes. Within the gravel bed channel of the river, however, the thread of the stream has shifted substantially, and a braided stream pattern is emerging on the mainstem from RM 5.5 up to the confluence (RM 9) and continuing up the lower 2 miles of the South Fork. In addition, the riverbed has been aggrading.

Bank erosion was particularly severe and threatening at two locations at the time of the Preliminary Draft CFCMP (1988). In the vicinity of the Skokomish Community Church

BASE DATA:

U.S. GEOLOGICAL SURVEY 7.5 MINUTE QUADRANGLE SERIES MAPS AS FOLLOWS;

SKOKOMISH VALLEY, 1986 PROVISIONAL EDITION
UNION, 1985 PROVISIONAL EDITION

THE FOLLOWING 15 MINUTE QUADRANGLE SERIES MAP, A PORTION ENLARGED APPROX. 200%;

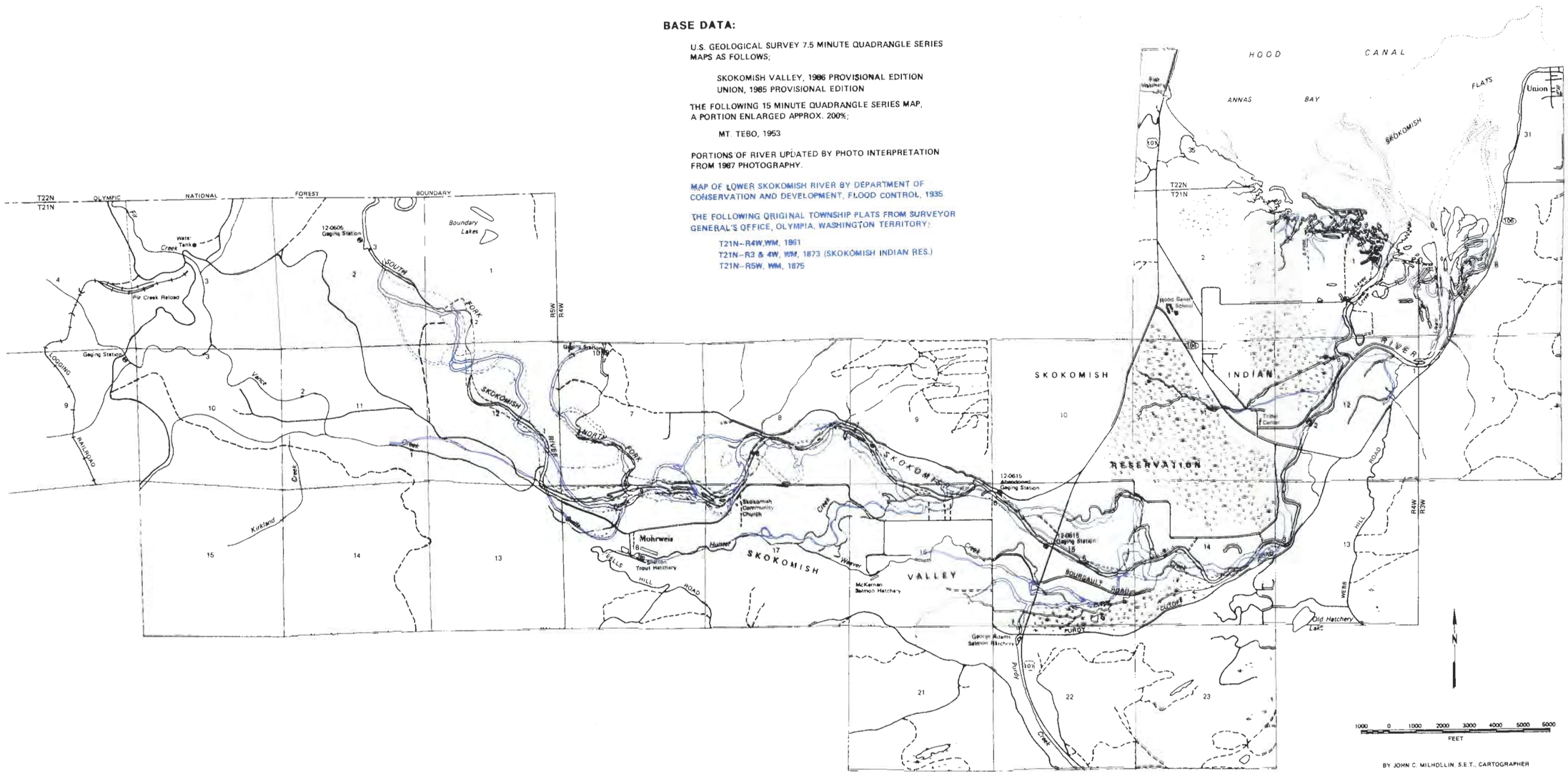
MT. TEBO, 1953

PORTIONS OF RIVER UPDATED BY PHOTO INTERPRETATION FROM 1987 PHOTOGRAPHY.

MAP OF LOWER SKOKOMISH RIVER BY DEPARTMENT OF CONSERVATION AND DEVELOPMENT, FLOOD CONTROL, 1935.

THE FOLLOWING ORIGINAL TOWNSHIP PLATS FROM SURVEYOR GENERAL'S OFFICE, OLYMPIA, WASHINGTON TERRITORY;

T21N–R4W,WM, 1861
T21N–R3 & 4W, WM, 1873 (SKOKOMISH INDIAN RES.)
T21N–R5W, WM, 1875



SOURCE: Ecology, 1988.

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Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 3-4.
SKOKOMISH RIVER CHANNEL PATTERNS, 1861-1987

(RM 8.1 - 8.3), the gravel bed of the river was widening and the right bank had eroded to within 50 to 70 feet of Skokomish Valley Road. At RM 1.8 on the South Fork, the gravel bed was widening and the right bank had eroded to within 50 feet of Skokomish Valley Road. Current locations where bank erosion is at a critical stage, including the right bank in the vicinity of the Skokomish Valley Church, are discussed in Chapter 6.

Riverbed Aggradation

Local residents report that the mainstem riverbed is filling with gravel or rising. Typical of Puget Sound lowland rivers, the mainstem meanders of the Skokomish River are dynamic and shifting. Gravel bars form, migrate, and reform annually. Riverbed filling, more properly aggradation, is caused by the deposition of sediment. Aggradation is a dynamic process subject to seasonal and long-term changes in rate, including reversals, or erosion.

Magnitude of Aggradation

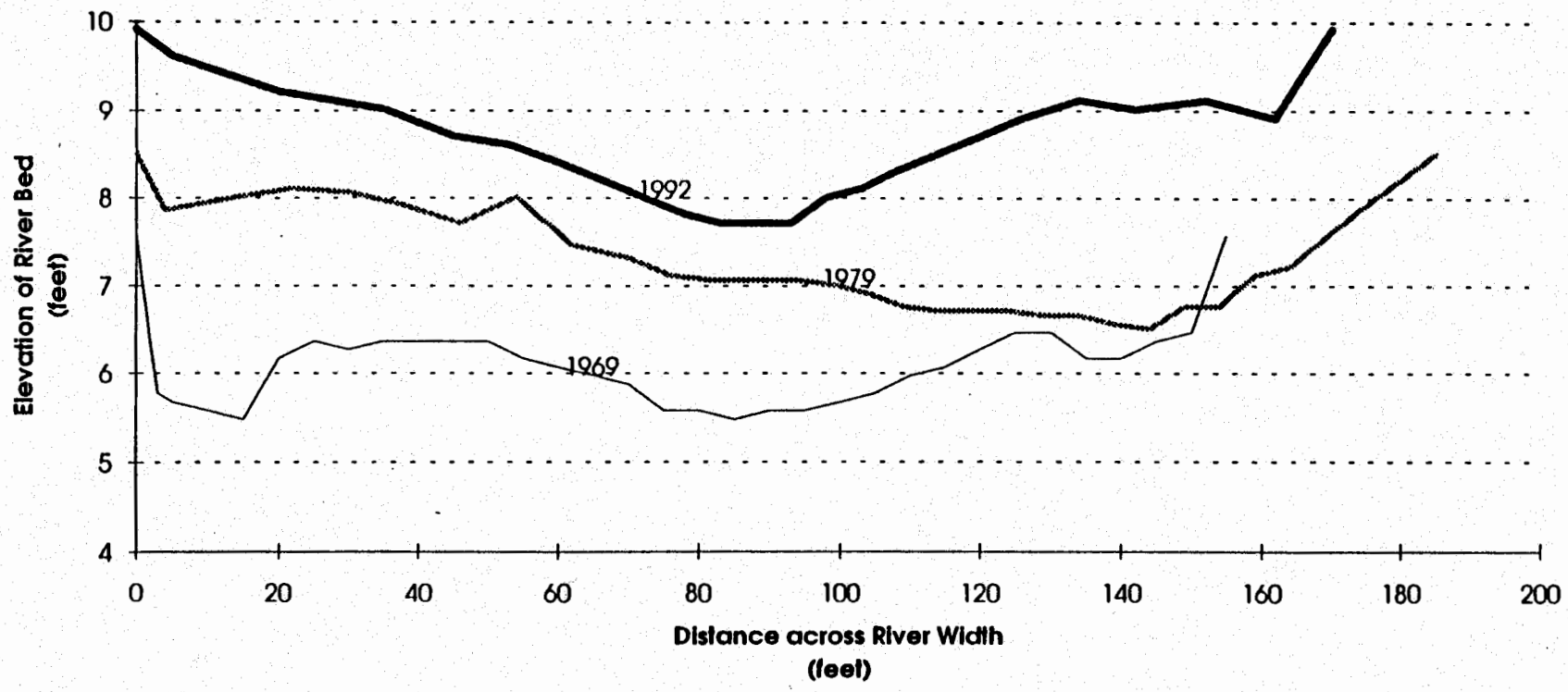
The diversion of flows from Lake Cushman has reduced the Skokomish River's sediment carrying capacity. The following results have been attributed to this reduction (Watson 1992; Jay 1992; Simenstad 1992):

- Increased riverbed elevations
- Increased overbank flooding
- Deposition of finer-grained materials in the streambed
- Reduced water and sediment delivery to the Skokomish River delta
- Reduced biological capability of the mainstem Skokomish River.

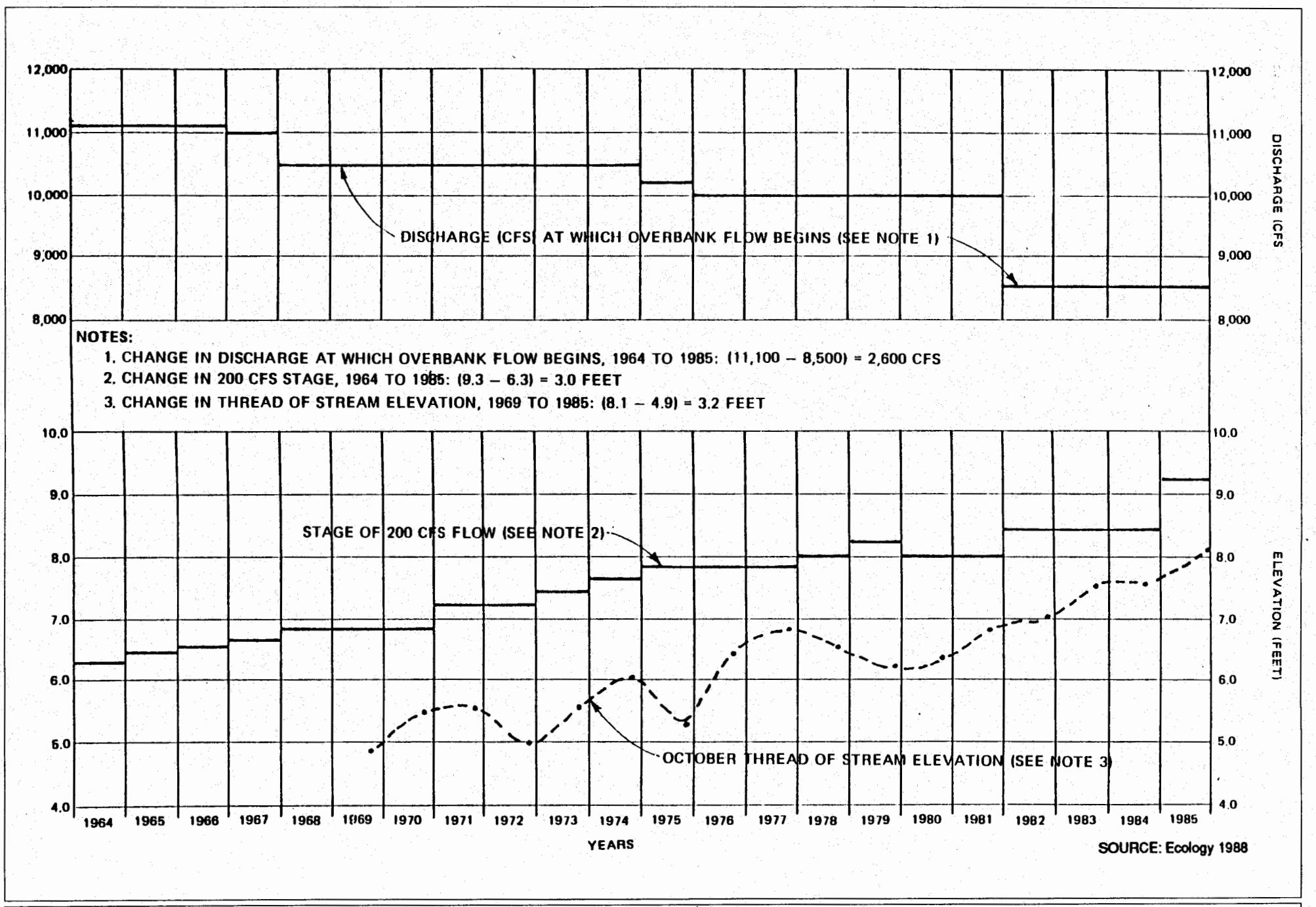
While the flow diversion has reduced the river's ability to carry sediment, extensive logging in the South Fork watershed may have increased sediment loading in the South Fork Skokomish River (Jay 1992; Simenstad 1992; Jay and Simenstad 1992). Because the reduced flows in the mainstem Skokomish are insufficient to transport the sediments to the delta, any increase in sediment load from the South Fork would exacerbate the aggradation problems in the mainstem.

Residents maintain that the cause of the aggradation is a reduced capacity of the river to flush sediment. Reduced flows from the North fork and a corresponding reduction in the river's ability to scour the channel are often cited. Proving that the reduction of flows from the North Fork and the production and transport of sediment from the South Fork has caused aggradation and related effects is difficult with existing data.

Cross-sections of the channel upstream of the US 101 bridge support the assertion that the channel is aggrading. Channel cross-sections near the USGS gauge upstream of US 101 at Potlatch show a two-foot increase in the bed elevation from 1969 to 1992. These cross-sections are plotted in Figure 3-5. A similar analysis by Ecology (1988) shows a three-foot rise in riverbed elevation at this location (Figure 3-6). An increase in the riverbed elevation reduces the available flow area, and flooding may occur at lower flows.



KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 3-5. SKOKOMISH RIVER SECTIONS NEAR THE USGS GAGE AT POTLATCH



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Mason County
SKOKOMISH RIVER COMPREHENSIVE
FLOOD HAZARD MANAGEMENT PLAN

Figure 3-6.
SKOKOMISH RIVER CHANGES
AT HIGHWAY 101 BRIDGE

River channel and Valley cross-sections at other locations were surveyed by FEMA in 1980, by the County in 1989, and by TPU in 1992. Plotted cross-sections from the 1980 and 1989 surveys are included in Appendix N. The cross-sections in Appendix N-1 are of the entire Valley; those of Appendix N-2 are enlargements of the river channel portion of each surveyed Valley section. In comparing the two surveys, two concerns lead to difficulty in reaching definitive conclusions about changes in riverbed elevations along the Skokomish River.

The first is that the nine-year period between surveys is not long enough for documenting long-term historical changes in a river system. Many transient changes along the river, such as changes in meander patterns and local scour, can cause local increases or decreases in bed elevations that are not representative of historical changes along an extended reach of the river.

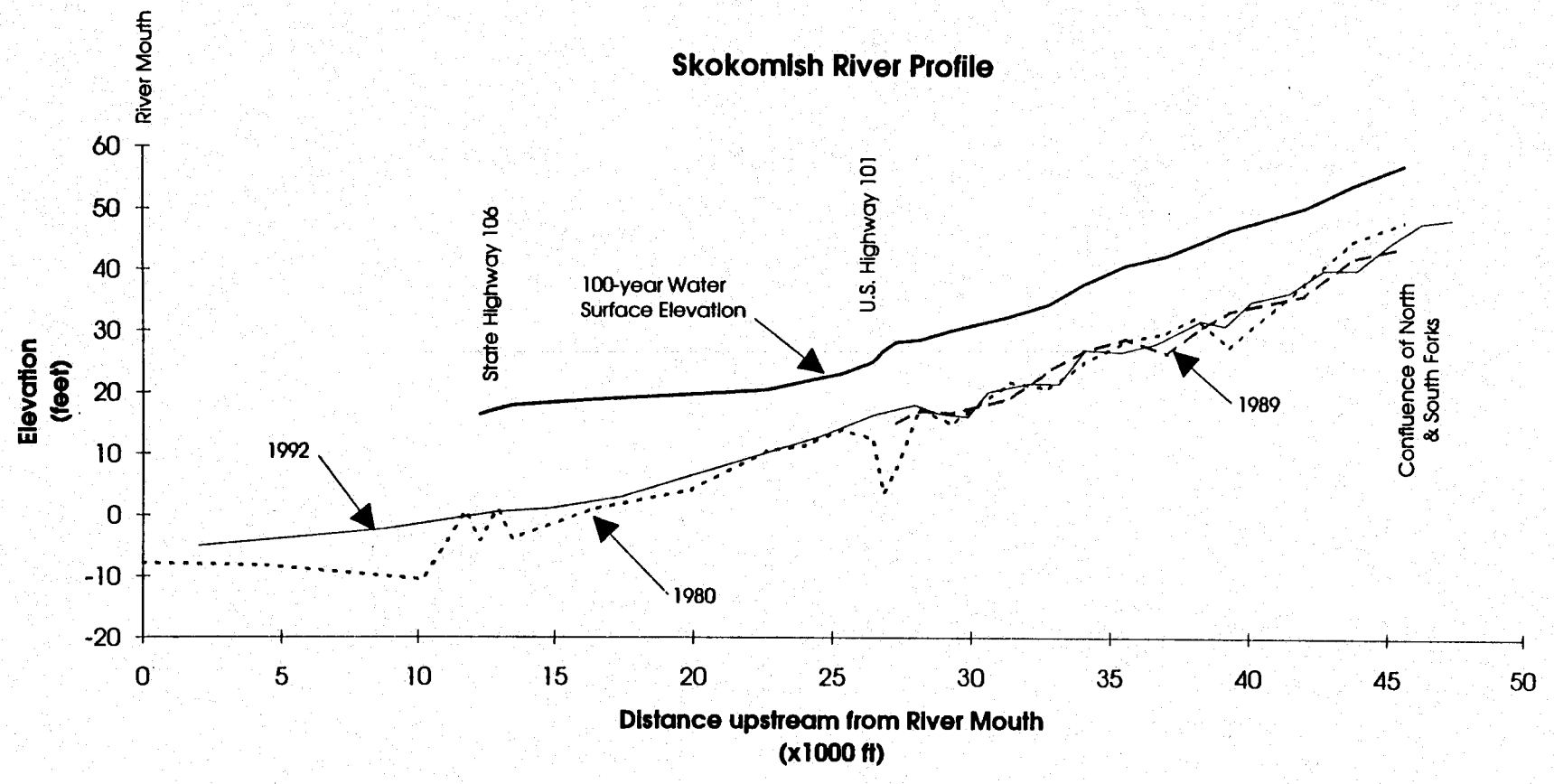
The second, more important, concern is the accuracy of the 1980 FEMA survey. While changes in the active river channel can be expected, the surveyed sections across the Valley should be similar in the two surveys. The plotted Valley cross-sections in Appendix N often differ in ground elevation by up to five feet between the surveys. The County considers its 1989 survey, conducted by a local survey firm, to be extremely accurate. The origin and accuracy of the 1980 survey could not be confirmed. Concerns about the 1980 survey affect the credibility of conclusions based solely on a comparison of the 1980 and 1989 surveys, and also leads to questions about the flood elevations determined by FEMA (1988) using data from this survey.

Figure 3-7 shows the mainstem Skokomish River thalweg profile from the confluence of the North and South Forks to US 101 for the 1980, 1989, and 1992 surveys. The thalweg is defined as the lowest point in a channel cross-section. This can be similar to other bed elevations across the channel in the case of a relatively uniform, horizontal bed, or it can represent a local low point such as can occur at scour areas or at the outside of channel bends. Comparison of the thalweg profiles in Figure 3-7 shows that the minimum bed elevations have varied between surveys. As discussed above, there are concerns about the accuracy of the 1980 FEMA survey.

One area of interest in Figure 3-7 is near the US 101 bridge. The 1980 survey indicates that this site may have been a local scour area. If so, this leads to the question of whether the river deposition documented by USGS data in Figures 3-5 and 3-6 is representative of the river reach, or is just infilling of the local scour area. Again, concerns about the accuracy of the 1980 survey restrict definitive conclusions based solely on a comparison of the 1980 and 1989 surveys.

Upstream of the US 101 bridge, it is difficult to see consistent differences among the three surveys. However, from 1989 to 1992, the surveys show a two-foot rise in the river bed elevation at the USGS gauge location upstream from the bridge. This is consistent with the USGS cross-section data. Also, downstream of the US 101 bridge there is a noticeable increase in bed elevations from 1980 to 1992. It is interesting to note that during this period there were major flood problems, in 1987, 1990, and 1992.

The sediment deposition illustrated in Figures 3-5 and 3-6 is based on USGS data for the extended period from 1969 through 1992. These data illustrate a continuous and gradual infilling of the channel over this period. Because the USGS data are for a longer time period than the 1980 to 1989 period covered by the FEMA and County surveys, and the data are considered accurate, channel aggradation at this location is the most reasonable conclusion based on the available information. This is consistent with the observations of Valley residents and the Skokomish Tribe, who have lived along the river for many years.



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SKOKOMISH RIVER COMPREHENSIVE
FLOOD HAZARD MANAGEMENT PLAN

Figure 3-7.
SKOKOMISH RIVER
LONGITUDINAL BED PROFILES

The diversion of about 90 percent of the North Fork out of the basin at Lake Cushman reduces the sediment transport capacity of the mainstem of the Skokomish River. The role of historical forest practices in the upper Skokomish River basin in increasing sediment inflow to the river is discussed in Chapter 6. While long-term definitive river survey data are not available, both conditions would accelerate natural sediment deposition tendencies as the North and South Forks flow from steep valleys and form the mainstem in the flatter, wide, lower Valley.

Sediment Monitoring and Transport Modeling for FERC

As part of the materials submitted to FERC for re-licensing of the Cushman Hydroelectric Facilities, TPU's consultant, Simons and Associates, prepared technical reports documenting flow and sediment monitoring, and modeling analyses and results related to aggradation on the mainstem Skokomish River. Specifically, the reports describe the magnitude of aggradation and flooding simulated for scenarios with and without the Cushman Project, and discuss the magnitude of flows and season in which aggradation occurs at US 101:

> Sediment analysis and modeling was conducted for both the with and without Project scenarios. The analysis shows that even under natural flow conditions without the Project, sediment deposition occurs. Coarser sediment sizes produced by erosion and transported from the steeper reaches upstream simply can not be transported from the steeper reaches without the Project. This confirms the geomorphic analysis [that the flattening of the bed slope and resulting reduction in velocity and energy to transport sediment foster a natural tendency for sediment to deposit in the lower river, delta, and estuary].
>
> The water surface profile was determined after routing 47 years of flows both with and without the Project. The analysis shows that on average there would be 0.85 feet of sediment deposition in the Skokomish River without the Project and an additional 0.93 feet of sediment deposition totaling 1.78 feet with the Project. The difference in sediment deposition between the current case and the non-project case averages about 0.02 feet (about 1/4 inch) per year. This relatively low rate is not expected to significantly change in the future. Even with this additional deposition, because of the reduction in flow due to the Project, the water surface elevation is still, on average, 1.66 feet below the without Project case.
>
> The additional sediment deposition with the project does not translate directly into an equivalent increase in flood stage for two reasons. First, with the project, the peak flows are substantially decreased. Second, the deposition is not uniform along the channel for either case resulting in less of a difference in water surface elevation than indicated by average change in bed elevation. Thus, with regard to flooding, the reduction in flow due to the Project is more significant than the additional sediment deposition caused by the reduction in flow (Simons and Associates 1993).
>
> Both the model results and data show that the river bed at the Highway 101 bridge is experiencing aggradation during the low and moderate flow portion of the season with relatively abrupt scour as a result of high flow events. Once the high flow event has passed, the river continues on its trend of aggradation (Simons and Associates 1995).

Impact on Delta

An oceanographer and a coastal marine ecologist from the University of Washington who studied the Skokomish River delta concluded that the reduced flow in the Skokomish River is having detrimental effects on the river's delta and estuarian wetlands (Jay 1992; Simenstad 1992; Jay and Simenstad 1992). In an undisturbed river and delta system, the sediment naturally eroded away from the outer edge of the delta would be replaced with new sediment transported downstream by the river. Reducing the flow in the river has upset the balance of sediment erosion and replenishment in the river's delta. The sediment-transport capacity of the river has been reduced and the delta no longer receives its historical volume of sediment. The sediments that reach the delta now are finer than prior to construction of the Cushman Project and are deposited higher in the delta, with less being transported to the outer edges of the delta. Meanwhile, the natural erosive processes continue at the outer edges of the delta. The net result is a steepening of the delta surface slope and reduced biological productivity in the delta.

Steepening of the delta face has reduced the area of the low intertidal zone between the +2-foot and -3-foot contours. This zone contains a variety of habitats that are ecologically significant for many species of plants, fish and animals. It has been estimated that the area between the -5-foot and 0-foot contours has been reduced by 42 percent as a result of the delta's steepening (Jay and Simenstad 1992). This has reduced the number of fish and shellfish the delta can support and the predator species that feed on them.

The steepening of the delta also affects saltwater intrusion. While no salinity measurements were taken prior to the construction of the Cushman Project, it is generally accepted that steepening of a delta will increase salinity at the outer edge of the delta while decreasing it in the inner delta nearer the river mouth. This type of salinity change has a negative affect on anadromous fish such as Pacific salmon (Jay and Simenstad 1992). These conclusions support those of a previous investigation performed for the Skokomish Tribe (Watson 1992).

A further discussion of changes in the Skokomish Delta is presented in Appendix F, containing excerpts from the DEIS for the Cushman Project.

GROUNDWATER HYDROLOGY

As discussed above, bed levels in the Skokomish River have risen with the deposition of sediments from upper portions of the watershed. This has caused water levels in the Skokomish River to rise as well. Valley residents believe the rising Skokomish River water levels have caused groundwater levels to rise in the Valley, leading to marshy land conditions.

This section examines the relationship between river levels and groundwater levels based on the hydrogeology of the Valley, assesses the effect of river levels on groundwater levels, and presents measurements from several locations in the Valley to support the hydrogeologic assessment. Other possible causes of increasing marshy lands are also discussed, but these have a more local effect and would not explain the valley-wide loss of productive farm land. Background on the geology of the area was discussed in Chapter 2.

Groundwater Resources

The alluvial aquifer, consisting of hydraulically connected surface and subsurface water components, is the major aquifer in the Skokomish River Valley. This aquifer includes the sand and gravel strata of the young alluvium of the Skokomish River and some sand and gravel of the Vashon Stade of the Fraser Glaciation. The Skokomish River lowland is mantled by clay and silt from 5 to 30 feet thick. Peat overlies this clay-silt sequence at several places in the lowland. The clay-silt sequence is underlain by clay, cemented gravel, and hardpan of low permeability, with some thin, interbedded, water-bearing sand and gravel layers. This sequence is underlain by sand and gravel that occurs, in general, within 40 to 60 feet of the ground surface in the vicinity of US 101 and SR 106 (Sections 2 and 11, T21N, R4W). The limited exploratory information available on the alluvial aquifer suggests that its thickness and lateral extent are significant. Based on limited subsurface data, the aquifer is estimated to be up to 100 feet thick (James and Martino 1980).

Regionally, the alluvial aquifer is unconfined to semi-confined. Unconfined aquifers are those in which the water table varies in undulating form and slope, depending on the areas of recharge and discharge. Semi-confined aquifers, a common feature of alluvial valleys, exist when the permeable stratum above the aquifer is overlain or underlain by a semipervious layer. The potentiometric surface, the water table in most places, occurs within 10 to 20 feet of the ground surface. Two relatively deep (94 and 100 feet), flowing wells exist on the Nalley property near the mouth of the river on the Skokomish Reservation. Both wells yield water under flowing artesian conditions. The rate of flow varies with the tide.

Groundwater occurs in several situations in the Skokomish valley. Some of the precipitation that falls as rain over the area, along with meltwater from snow, soaks into the ground and seeps downward to the zone of saturation to become groundwater under unconfined conditions. Where the groundwater moves downward to clay or hardpan layers, it may run off as springs where these layers come to the land surface. Where the groundwater continues seeping downward and laterally, to become trapped beneath clay or hardpan layers, it is confined under pressure. When wells are drilled to these confined artesian zones the water rises in the wells; flowing artesian wells occur where the water rises above land surface, due to lower elevation of the well than the point where the groundwater becomes confined beneath the clay. Some groundwater beneath the flood plain also results from downward seepage of water left standing after each flood. Groundwater beneath the floodplain may also come from seepage toward Hood Canal from water-bearing sand and gavel layers beneath the upland plain to the west. Groundwater beneath the upland plain comes entirely from percolation of local rainfall and snow melt (Molenaar and Cummans 1973).

Groundwater loss, or leakage, from beneath the floodplain occurs as seepage to Hood Canal and to the Skokomish River along the southern and eastern margins of the lowland. Loss of groundwater from saturated sand and gravel beneath the hills to the west also occurs as seepage from spring zones that feed the numerous small streams draining from the hills to the Skokomish River and floodplain (Molenaar and Cummans 1973).

The water table, the upper surface of the zone of saturation of water-bearing materials, is nearly flat and has a gentle slope toward the Skokomish River and Hood Canal. The slope of the water table closely follows the slope of the land surface, from the hills in the western part of the

reservation toward the Skokomish River and Hood Canal on the east and northeast (Molenaar and Cummans 1973).

The U.S. Geological Survey (USGS) reported the results of water level measurements taken approximately every two months in 14 wells during the period from May 31, 1972, to February 12, 1973 (Molenaar and Cummans 1973). The depth to water beneath the floodplain was generally less than 8 feet in most wells. The water levels fluctuated a relatively small amount, ranging from about one-half foot in a well on the floodplain to about 4 feet in a well at the base of the hillside at the western edge of the floodplain. An example of the monthly fluctuations at two wells near the George Adams Salmon Hatchery is shown in Figure 3-8. The small seasonal fluctuations in water levels are typical of wells on river floodplains where the materials are saturated at or near river level; the river provides the base level, below which the adjacent groundwater table will not drop, except locally at wells during pumping (Molenaar and Cummans 1973).

Groundwater Measurements

Because groundwater in the Skokomish River Valley is predominantly contained in an unconfined aquifer, groundwater levels in the Valley are affected by water levels in the Skokomish River and its tributaries within the Valley. Therefore, any rise in the river and creek water levels will cause a rise in groundwater levels in the valley.

To confirm the relationship between river levels and groundwater levels, measurements were obtained on February 23, 1993, by KCM, Mason County staff, and representatives of the Skokomish River Planning Advisory Committee. Five measurements were obtained in the Valley upstream of US 101, and two from wells on the Skokomish Indian Reservation. Locations of the measured wells are shown in Figure 3-9 and described in Table 3-5. Table 3-6 presents the results of the field investigation.

In addition, Figure 3-8, which illustrates the seasonal fluctuation of the water levels in the Emily Miller and J.A. Andrews wells, shows that the groundwater table in the Valley rises and falls with the water levels in the Skokomish River. In the figure, peak water table elevations were measured in February and March, when peak flows and associated river levels are highest in the Skokomish River. The elevation of the water table slowly decreased during the spring, and were lowest in September and October, when peak flows and associated river levels are typically the lowest.

TABLE 3-5.
LOCATION OF WELL MEASUREMENTS

Survey No.	Location of Well
1	Skokomish Community Church; Skokomish Valley Road
2	Skokomish Indian Reservation; N.E. corner of Reservation Road and Cedar Lane
3	Skokomish Indian Reservation; Reservation Road on west side; north of Cedar Lane
4	Jerry Richert's Property
5	Tozier Place; Skokomish Valley Road
6	Doak Place; Skokomish Valley Road
7	Crossan Property; Skokomish Valley Road and Deyette Road

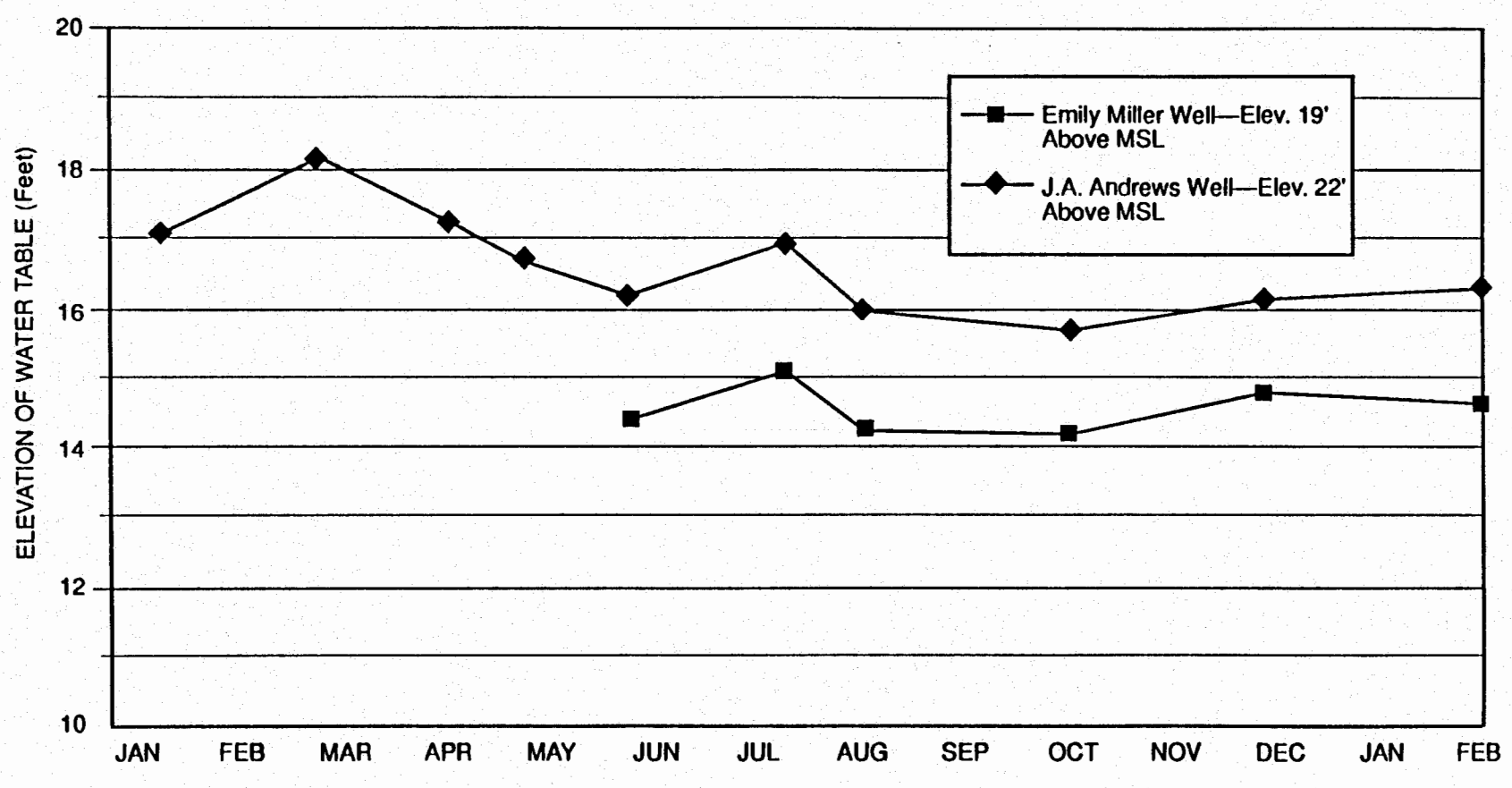

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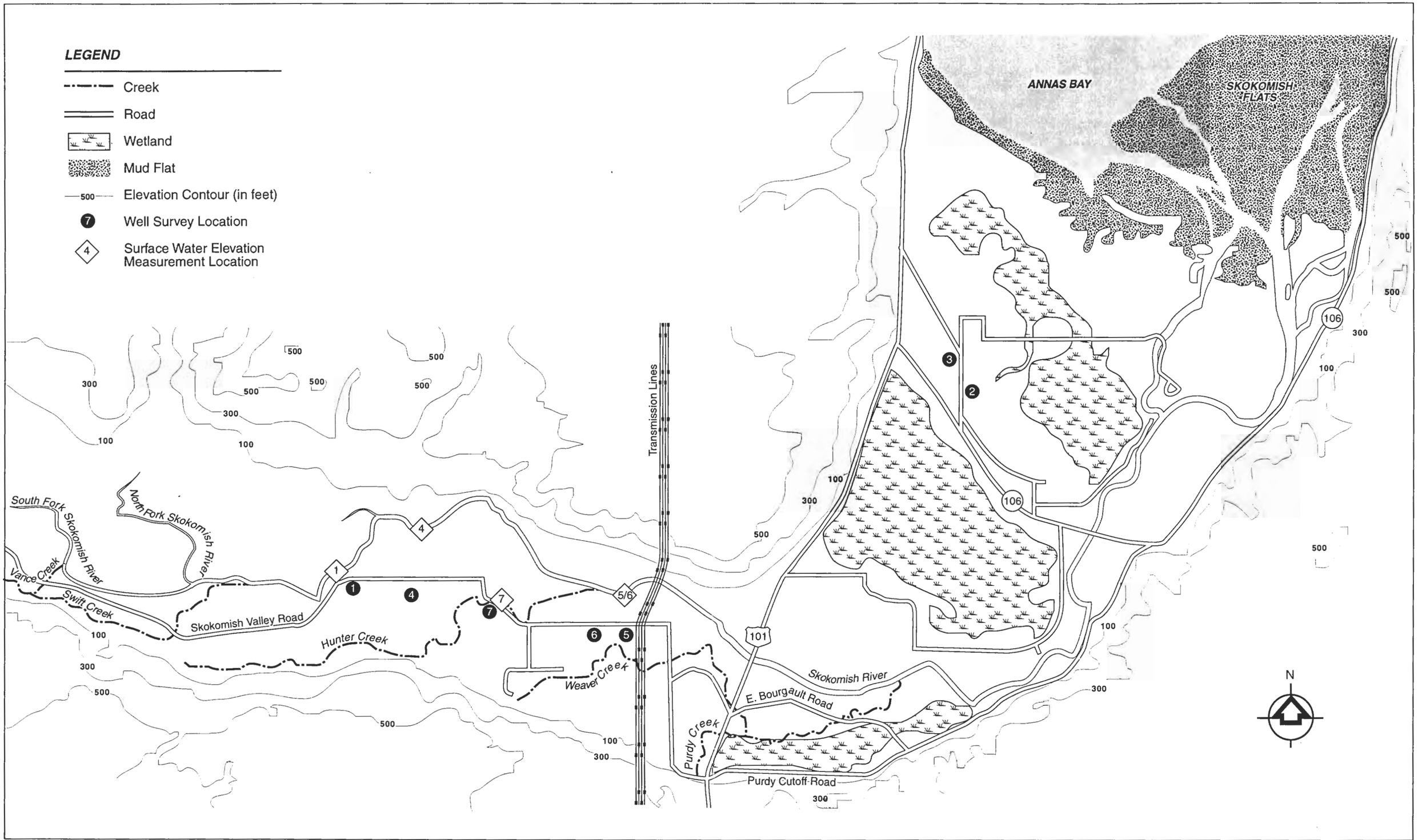
Figure 3-8.
SEASONAL FLUCTUATION OF WATER TABLE NEAR
GEORGE ADAMS SALMON HATCHERY, 1973-1974



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SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 3-9.
WELL SURVEY LOCATIONS

TABLE 3-6.
RESULTS OF FIELD INVESTIGATION

Well Survey No.	Depth to water as measured from ground (feet)	Depth to water as measured from top of well casing (feet)	Water elevation measured in well [a]	Water elevation measured at adjacent surface water body [a]
1	7.3	8.0	41.4	42.7
2	------ [b]	9.0	43.9	----- [b]
3	------ [b]	8.3	43.5	----- [b]
4	------ [b]	7.7	43.5	44.2
5	2.8	4.3	27.7	25.1
6	5.0	6.7	24.7	25.1
7	5.8	8.0	42.8	42.0

a. Relative elevations, surveyed from assumed benchmark elevations; used only to establish comparison between groundwater levels and river levels

b. No measurement taken

Other Possible Causes of Increasing Marshlands

Valley residents report that the water table under the Skokomish Valley, between US 101 and the confluence of the North and South Forks of the Skokomish River, appears to be higher now than in the 1950s. They base this observation on the increasingly marshy condition of farmland, and the current abundance of swamp grass (*Juncus effusus*) in the fields and pastures. *Juncus effusus*, commonly called softrush, is a common indicator of wet meadows and wet pastures in the Pacific Northwest.

Several other possible causes for the increasingly wet conditions of the farmland within the Skokomish River valley are possible. These causes have a more local effect and do not explain the valley-wide loss of productive farmland.

Lack of Adequate Drainage

It is possible that wet conditions persist on the land adjacent to the Skokomish River more readily now than several decades ago because of deteriorating drainage conditions on floodplain lands. In a floodplain, fine-grained sediments are deposited in the overbank areas during flooding and settle out of the floodwater as the water becomes ponded. This natural process results in the fine agricultural land found in most floodplain areas, but also leads to poorly drained soils. The increasingly wet conditions that residents have observed could be caused by the natural buildup of fine-grained sediments, retaining more water than previously and allowing wetland plant species to take hold.

James and Martino (1980) remarked on the lack of adequate drainage in the marshy area on tribal land between US 101 and SR 106:

> The River Road has the effect of inhibiting drainage of the South Bog, or main swamp area. This is especially true at the southeast corner of the swamp near

where the River Road intersects Highway 106 (Shannon and Wilson, 1978; Bauer, 1979). The River Road has inadequate drainage provisions and serves as a dike between the river and the swamp area. Flood waters flow over the road into the swamp, but drainage back to the river is severely restricted (p. 372).

Rise in Relative Sea Level

Recent research has indicated that relative sea level has risen an average of one foot in the last 100 years in southern Puget Sound. The cause of this rise is twofold. First, sea level may be rising worldwide and second, the Puget Sound area is an active tectonic area, which means that the land surface itself is moving. In southern Puget Sound, vertical land movements downward are responsible for the bulk of the rise in relative sea level. The land in the region of the marsh on Skokomish Tribal land ranges in elevation from 10 to 20 feet, based on existing USGS topographic maps. Because of the flat, low-lying nature of this area, a relative rise in sea level (connected to the groundwater body) could lead to expansion of the wetland area.

Localized High Water Table Caused by Meandering Filling

On the Skokomish Reservation, the increasingly marshy area adjacent to old river meanders in Section 14, T21N, R4W has been attributed to the filling of the outlet of the southerly meander into the mainstem (RM 4.1), causing a chronic, localized high water table (Canning et al. 1988; James and Martino 1980). Around 1940, an S-curve channel was bypassed and replaced with a 1,900-foot-long artificial channel. The work was done by the Civilian Conservation Corps (CCC), apparently at the request of the Mason County Commissioners. Based on Mason County Assessor's maps, it appears that the S-curve still served as a flood relief channel after construction of the new channel. Floodwaters still flow from the new channel into the upstream junction of the S-curve, but a local landowner has blocked the outlet, so the flows cannot exit. This situation impedes drainage of the main swamp and flood flows of the river.

Localized High Water Table Caused by US 101 Embankment

The construction of the US 101 embankment may have caused a localized increase in the groundwater levels. Data are not available to assess this possibility; however, the compaction of the soils underlying the roadway embankment may be sufficient to impede groundwater flow and cause localized high groundwater levels upstream from US 101.

CHAPTER 4.
FLOOD HISTORY

FLOOD CHARACTERISTICS

This chapter documents historical flood events and actions taken in response to them. Flood management activities have taken place in the Skokomish Valley for as long as the valley has been settled. A brief chronology of significant events relating to flooding and flood hazard management is presented in Table 4-1.

TABLE 4-1.
CHRONOLOGY OF EVENTS RELATED TO FLOODING AND FLOOD HAZARD MANAGEMENT IN THE SKOKOMISH VALLEY

Year	Event
1924	Original "Minor Part" license issued for Cushman Project, 50-year term
1942	*Report and Survey of Skokomish River, Mason County* completed by COE. Report recommends against approving flood control project for Skokomish River
1974	"Minor Part" license for Cushman Project expires, project begins operation under annual licenses, TPU submits re-license application
1975	Mason County enters the NFIP, receiving emergency status in August
1976	Mason County adopts Resolution 632 initiating the creation of the Skokomish FCZD in response to petitions from Valley residents asking the Commissioners to improve flood control and drainage
1977	Mason County receives a Flood Hazard Boundary Map from FEMA. FEMA requests that County complete flood damage prevention ordinance
1987	Extensive additions made in summer/fall to the system of levees in place at the time
1988	*Skokomish River Comprehensive Flood Control Management Plan Preliminary Draft Plan* completed by Ecology in March
1988	County Suspended from NFIP in March
1988	Mason County receives Flood Insurance Rate Maps from FEMA in May
1988	October memo from FEMA indicates that FEMA and County discussed options for floodway analysis, including split floodway and density floodway
1988	Affidavits concerning levee construction filed by representatives of Ecology in September and of FEMA in October; letter to Thurston County Superior Court from Assistant Attorney General of State of Washington dated December 1988 requests non-jury trial, judge, and court date in legal case relating to levees.
1988	Terms for proposed out-of-court settlement discussed by County, Ecology, and property owners at meeting on December 27. Terms include construction of a levee that will not raise 100-year flood levels by more than 0.5 feet and that will meet soil erosion standards

TABLE 4-1. (continued)
CHRONOLOGY OF EVENTS RELATED TO FLOODING AND
FLOOD HAZARD MANAGEMENT IN THE SKOKOMISH VALLEY

Year	Event
1989	"Trial Brief of Plaintiffs for Injunction and Abatement" signed by Attorney General in September, filed in Superior Court in Thurston County. Case deals with "construction of a levee or dike in the Skokomish River Floodway without benefit of a shoreline substantial development permit under Ch. 90.58 RCW and contrary to flood control policy under CH. 86.16 RCW." Brief requires that "levee must be abated as a public nuisance."
1990	November flood event is second largest flood of record, peak height on Skokomish at Potlatch, November 23, is 16.80 feet. Peak discharge estimated at 36,600 cfs.
1991	Board of Mason County Commissioners passes Flood Damage Prevention Ordinance. Ordinance adopts Flood Insurance Study as "Interim Regulations" that "shall be replaced using a comprehensive planning process which recognizes the role of diking in flood control management efforts"
1992	Work Begins on Final Draft CFHMP, Planning Advisory Committee established
1993	*Skokomish River Comprehensive Flood Hazard Management Plan - Volume II - Draft* completed by KCM. Report focuses on river and valley creek maintenance, flood protection including establishment of a low-level set-back berm, and flood warning and emergency response.
1993	Work begins on *Watershed / Ecosystem Improvement Action Plan.* Project led by Skokomish Tribe.
1994	December flood event is largest flood of record, peak gauge height on Skokomish at Potlatch, December 20, is 17.5 feet. Discharge estimated between 30,000 and 40,000 cfs (see Chapter 5), approximately equal to or greater than the 100-year event
1995	*Key Elements of the Skokomish Valley Comprehensive Flood Hazard Management Plan* adopted by PAC in May
1995	*Skokomish River Comprehensive Flood Hazard Management Plan - Draft Chapters* completed by KCM in June. Report focuses on flood hazard analysis, property acquisition, flood audit, development regulation including density floodway
1995	Letter from Mason County Board of Commissioners informing FERC of CFHMP process and requesting that "any monetary damage assessment funds be channeled through Mason County for restoration and repair of the Skokomish River"
1995	*South Fork Skokomish Watershed Analysis* completed in June
1995	DEIS for the Cushman Project completed in November
1996	Draft Skokomish CFHMP completed in April; Public Workshop, Planning Commission hearing, and Board of County Commissioners hearing held in November and December, Plan adopted December 30, 1996 (see Appendices OO, PP, QQ, and RR for comments on draft plan and materials relating to the adoption process).

Pre-Settlement Records

Prior to European settlement, the Skokomish Valley was drained by numerous sloughs and ancient meanders of the mainstem of the Skokomish River. Based on a review of the GLO land

survey field notes of 1861, the Skokomish Valley was densely covered by willows, Douglas spiraea, vine maple, salmonberry, and other shrubs associated with wet or periodically flooded soils. The forest trees were a mix of willow, red alder, black cottonwood, and western redcedar, also indicative of wet or seasonally flooded conditions. Some western hemlock and Douglas fir were found on higher ground. The survey work was conducted during September 1861; the surveyor noted that few portions of the valley were inundated or swampy at the time.

Historically, the lowland reaches of the larger Pacific Northwest rivers have been characterized by multiple channels, numerous sloughs and old side-channels, and an abundance of snags and logjams in the channels. Stream flow through the multiple channels was sluggish, and during the winter rainfall and spring snowmelt seasons the river regularly overtopped the channel banks and spread across the entire floodplain for days or weeks at a time, if not for the season. Soon after settlement by Europeans, a program of river snagging was begun by farmers, and later institutionalized by the COE, to hasten the drainage of peak flows and drain the floodplain land for agriculture (Sedell and Froggatt 1984; Sedell and Luchessa 1982).

The Skokomish mainstem is probably typical of Pacific Northwest lowland rivers. In 1861, the surveyor subdividing Township 21 North, Range 4 West, surveying north between Sections 15 and 16, arrived at the right bank of the Skokomish River and recorded in his notes that "at this point there is a large raft of timber in the river from one bank of [the] river to the other, upon which I chain [measure] across." There were probably other logjams in the river at that time, and even today the Skokomish mainstem contains logjams periodically, though not that a person can walk across.

The Skokomish Valley also exhibited characteristics typical of intricate drainage by numerous sloughs (but not multiple channels); the 1861 GLO survey maps of Township 21 North Range 4 West and 5 West show a floodplain drained by up to six old channels and sloughs across the valley bottom. Although many of these drainages have since been filled or plowed over, even today the Skokomish Valley shows many drainages and swales that are the remnants of ancient sloughs and meanders of the mainstem (FEMA 1987).

1973-1974 Observations

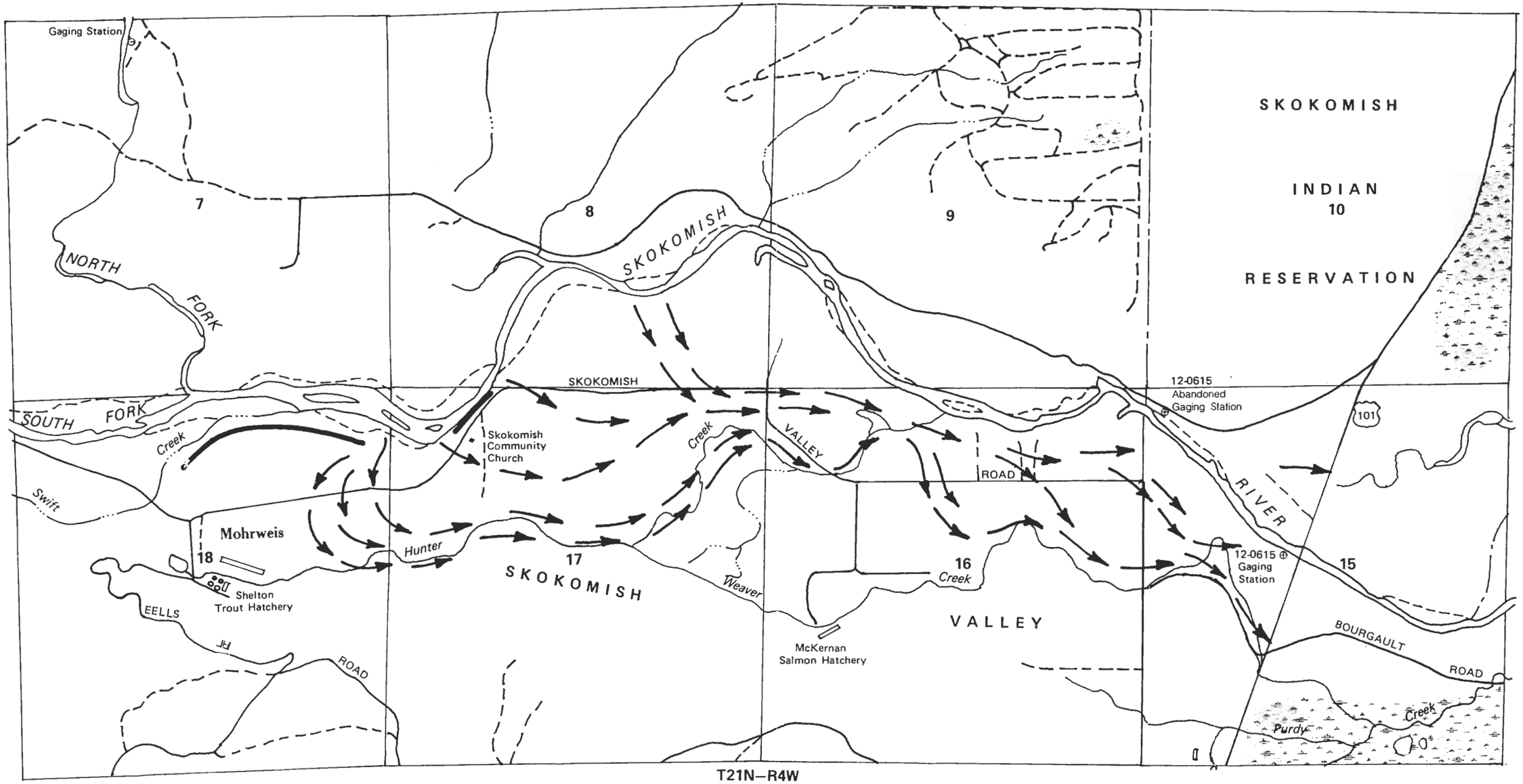
Molenaar and Cummans (1973) described flooding on the Skokomish Indian Reservation as

> common and usually occurring during periods of heavy rainfall in winter. Floodflows are characterized by rapid increases in flows within a few hours, followed by decreases to small flows with 2 or 3 days. Several floodflows occur each year, often in close succession. Such flows have been recorded on the North Fork since 1913, on the South Fork since 1932, and on the Skokomish River main stem since 1943. However, Cushman Dam No. 1 has partially regulated floodflows on the North Fork since 1926, and since then the large streamflows in the lower valley are almost entirely from the South Fork basin.
>
> At streamflows of about 2.1 million gpm [4,680 cfs] past the gaging station [US 101 bridge], the water begins to overflow the channel and flood adjacent lowland. Discharges of at least this much occur several times a year, generally during December through March.

> At least some parts of the reservation are covered by floodwaters approximately 10 days each winter, averaging 1 day each in November and March, 2 days in February, and 3 days each in December and January. The longest periods of flooding were 13 days in December 1966 and 18 days in January 1953. Flooding has occurred as early as October and as late as May.

In a publication for the Department of Interior, Cummans (1974) described flood distribution and characteristics of the Skokomish Valley as follows:

> Three principal streams—the North and South Forks Skokomish River and Vance Creek—join to form the main stem Skokomish River which flows for 9 miles (14.5 km) in the lower valley. Vance Creek, with a drainage area of 24.8 sq mi (square miles) or 64.2 sq km (square kilometers) and the South Fork Skokomish, with a drainage of 104 sq mi (269 sq km) are unregulated. The North Fork (118 sq mi or 257 sq km) is regulated, and at Cushman Dam No. 2 [Lower Cushman Reservoir] (drainage area 99.2 sq mi or 257 sq km) the entire flow normally is diverted to a power plant on Hood Canal. Infrequent spills and releases down the North Fork and natural runoff from about 19 sq mi (49.2 sq km) below the dam constitute the source of stream flow from this tributary. Potential floodflows from the area upstream from the dam are significantly reduced or excluded by the regulation and diversion.
>
> Overbank flooding was observed during this study [1970-1972] in the main stem Skokomish River. Flooding appears to occur first at points downstream from US Highway 101. At a river discharge of 4,650 cfs (cubic feet per second) or 132 cms (cubic meters per second) at profile station 9 [US 101 bridge], shallow overbank flow was observed to be spreading in the NE1/4 Section 15, the northerly 3/4 of Section 14, the S1/2 Section 11, the NW1/4 Section 12, and the SW1/4 Section 1, T21N, R4W. Discharges in the lower reach of the river exceed 4,650 cfs (132 cms) several times each winter and therefore parts of the valley floodplain downstream from US Highway 101 are submerged frequently. From records of flow obtained since 1943 at the US Highway 101 gage, some degree of flooding is estimated to occur in this reach on a yearly average of 1 day in November, 3 days in December, 3 days in January, 2 days in February, and 1 day in March. During the flood of January 20, 1972, discharge of 18,500 cfs (524 cms) and stage of 26.3 ft (feet) or 8.02 m (meters), water was observed at a depth of 8 ft (2.44 m) in some low spots in the E1/2 of Section 14.
>
> Upstream from US Highway 101 the channel presently appears to contain flows of approximately 8,900 cfs (252 cms) at a 24.4 ft (7.44 m) elevation at profile station 9 [US 101 bridge]. At flows greater than this, overbank flooding occurs in the E1/2 Section 18, T21N, R4W, with water overflowing south across the county road. The south riverbank also is topped in Sections 17 and 8, and, at higher flows, in Sections 9 and 16. Specific information was not obtained regarding flooding along the entire county road in N1/2 Section 16 and N line Section 17. Flows greater than 8,900 cfs (253 cms) have occurred at least once each year since 1943, and as many as six times during 1 year. In only two water years since 1943 (1946 and 1962) was overbank flooding upstream from US Highway 101 considered insignificant at the times of peak annual flows.



LEGEND:

DIRECTION OF FLOW DURING ANNUAL FLOODING

EXISTING DIKES

BY JOHN C. MILHOLLIN, S.E.T., CARTOGRAPHER

SOURCE: Ecology, 1988.

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HAZARD MANAGEMENT PLAN

Figure 4-1.
SKOKOMISH VALLEY ANNUAL FLOODING PATTERNS FROM
CONFLUENCE OF NORTH AND SOUTH FORKS TO HIGHWAY 101

1988 Observations

In 1988, Wes Johnson, a Valley resident and member of the Skokomish FCZDAC, characterized the annual flooding of the Valley between the forks and the US 101 Bridge (see Figure 4-1) as follows:

> The Mohrweis area is protected from low-level annual flooding by a dike along the right bank of Swift Creek extending from Skokomish Valley Road downstream to the main stem, and then runs along the right bank of the main stem to about the Section 18-17 line (T21N, R4W).
>
> This dike appears to be well constructed and properly compacted, and is covered by moderately dense vegetation, which protects the dike against erosion. At the end of this dike, approximately RM 8.4, flood waters flow south onto the floodplain and west behind the dike, then south across the Skokomish Valley Road to Hunter Creek on the south side of the Valley.
>
> A short, low, marginally effective dike has been erected along the north side of Skokomish Valley Road at the Skokomish Community Church. The dike appears to be mostly loose fill with inadequate vegetation to resist erosion. Overbank flow occurs at each end of this dike (RM 8.3 and 8.1), and the flood waters flow southeast across the Valley into an old, plowed-over creek channel, and then east into Hunter Creek. Christmas tree plantations in this area are clean-cropped (that is, no ground cover is maintained) and are susceptible to sheet and gully erosion during flooding.
>
> Flood waters are also known to escape the river at about RM 7.5 in Section 8, T21N, R4W, and flow south and southeast past the fire hall and grange hall and across Skokomish Valley Road, where of all the flood flows across the Valley merge.
>
> East of the Section 17-16 line (T21N, R4W) flood water flows across the Valley becomes complex. Overbank flows in Hunter Creek continue east toward the main stem. From the NE 1/4, NE 1/4, Section 17, flood waters flow east across Skokomish Valley Road south of the section corner to Sections 8, 9, 16, and 17; some of this flow may run to the north returning to the main stem at about RM 6.7; some of the flow probably runs to the south to merge with Hunter Creek overbank flow.
>
> In Section 16, flood waters flow east over the fields north of Skokomish Valley Road and south over the road at specific locations, and then into Weaver Creek.
>
> Flood water movements in Section 15 are thought to follow the pattern mapped, but there is uncertainty about the return of flood waters to the river. North of Skokomish Valley Road, flood water flows east and northeast over the old highway, and is thought to reenter the main stem at about RM 5.7. However, this is unconfirmed, and drainage swales evident on aerial photographs suggest that east of the Section 16-15 line, flood waters may move southeast toward Weaver Creek. Flood waters flowing southeast over the east-west segment of Skokomish Valley Road continue southeast across the north-south segment of the road, apparently merging with Weaver Creek overbank flows north of Bourgault Road. It is thought that some of the Weaver Creek overbank flow

> veers northeast and reenters the main stem at about RM 5.5, but this too is unconfirmed.

Information sources other than Mr. Johnson indicate that below US 101 flood waters enter the old slough and meander system north of the mainstem in Section 15, T21N, R4W, and flow under the highway 0.2 mile north of the mainstem. In recent years, however, the inlet to and outlet from the old slough and meander system has been filled, impeding the movement of flood waters. The filling of the meander system outlet at about RM 4.1 has apparently resulted in the chronic high groundwater conditions in NE 1/4, Section 14 as reported by Skokomish Tribal members, in addition to detaining flood waters.

US 101 and Skokomish Valley Road (old US 101) are built on fill where they cross the Valley in Section 15; these road fills act as low dams, holding back flood waters. At times of severe flooding, both roads are inundated. The Skokomish Valley Road fill impounds low level flood waters in S 1/2, SE 1/4, Section 16, T21N, R4W. The US 101 fill impounds low-level flood waters in NW 1/4, SW 1/4, Section 15, T21N, R4W.

HISTORICAL FLOOD CONTROL MEASURES

Development in the Skokomish Valley since European settlement has always included efforts to contain and open the channels of the Skokomish River and its tributaries. Residents have worked individually and collectively to keep the river clear of debris and to stabilize the stream banks where there has been erosion. Sediment has been periodically removed from river bars; overflow channels have been filled and side channels have been blocked; small drainages on the valley floor have been plowed over. Residents have made a consistent effort with limited resources to manage the adverse affects of the Skokomish River on agricultural land.

Puget Sound and Adjacent Waters Study

Early flood control activities were described in the Puget Sound and Adjacent Waters (PSAW) Study as follows:

> Bank Protection and Stabilization. Improvements by local interests, aided by the Public Works Administration and the Works Progress Administration, have been directed largely toward the prevention of bank erosion. Bank protective works constructed prior to 1936 along the right bank of the Skokomish River at various points consisted of training levees and revetments. In 1936 and 1937, the Works Progress Administration placed four log-floated shear cables, totaling 7,900 feet in length, across the bends where most of the erosion was taking place, and cleared the old channel bed along the northern bank opposite the cables. The purpose of the cables was to catch debris and divert the stream into the cleared channel. In 1940, local interests extended and strengthened one shear cable and improved the lower portion of Vance Creek channel. The shear cables have provided some small local benefits, but have not accomplished their primary purpose.
>
> Levees. A landowner has diked a large portion of the island between the two channels at the mouth of the river and some land west of Nalley's Slough. This

land was formerly subject to frequent inundation by high tides and high river flows.

Upstream Storage. Tacoma City Light has constructed two dams on the North Fork of the Skokomish River and operates two hydroelectric plants that have a combined maximum head of 735 feet. Cushman Dam No. 1 is approximately 9 miles above the mouth of the North Fork. The reservoir, Lake Cushman, is 9.6 miles long, covers 4,200 acres, and has a usable storage capacity of 360,00 acre-feet. Cushman Dam No. 2 is a re-regulating project approximately 6 miles above the mouth of the North Fork with a reservoir 2 miles ling. The reservoir has a storage capacity of 8,000 acre-feet. A tunnel 17 feet in diameter and 2.5 miles long leads to the powerhouse on Hood Canal near Potlatch. The Federal Power Commission license for these reservoirs does not provide for formal flood control storage; however, Tacoma City Light has held the level of Lake Cushman about 10 feet below the spillway elevation during the flood season to provide some flood storage. This voluntary action has reduced the magnitude of floodflows in the Skokomish Valley.

In 1931, Tacoma City Light obtained a preliminary permit from the Federal Power Commission for a proposed power project on the South Fork. Application for a license was filed on 7 September 1954. The city proposed to increase the power output of Cushman Projects 1 and 2 by diverting water from the South Fork reservoir through a tunnel to Lake Cushman. This proposed project would have a total storage capacity of 225,000 acre-feet. Application was filed on 8 July 1963 by the city of Tacoma to withdraw its application for license. Permission was granted by the Federal Power Commission on 27 August 1963 (Flood Control Technical Committee 1970).

Records of Historical Floodproofing

Information on the floodproofing of residential and nonresidential structures has not been effectively recorded to date. In many cases, Mason County building permit and assessor records do not reflect floodproofing or flood damage repair work. Some residential structures have been raised to reduce flood damages. Until the recent completion of the Mason County detailed flood insurance study by FEMA, no adequate information was available to establish a base elevation for floodproofing. Nonresidential structures, primarily agricultural structures, have experienced repeated flooding and have typically not been constructed with floodproofing considerations, such as orientation of flood flows, in mind.

Structural Projects

This section summarizes information on historic instream and bank measures based on discussions with Skokomish Valley residents, available records on state flood control cost-sharing projects, HPA permits dating back to 1980, and state Flood Control Zone Permits. Unfortunately, SCS and Mason County Soil and Water Conservation District records, the most detailed information on historic activities, have been destroyed with no summaries made of the information they contained.

State Flood Control Participation

From 1949 through 1973, Mason County and the State of Washington shared the cost of ten flood control work projects throughout the Skokomish Valley, with the state contributing almost 50 percent of the cost. The majority of the projects were sediment removal from river bars and debris removal for the purpose of maintaining the channel capacity and reducing bank erosion. Records do not indicate the location or volumes of material removed from either the Skokomish River or Vance Creek. Flood control cost-share work is summarized in Appendix O.

The first major rock revetment project was constructed on Vance Creek in 1950 and included sediment removal and the placement of a groin. An extensive dike, which extends along the left bank of Vance Creek for almost a mile and has alleviated the regular historic flooding, appears to have been constructed in 1953. Another major project during 1953 included changing the alignment of the Skokomish River and diking portions of the valley adjacent to the mainstem. It is unknown why the dike was not constructed continuously, but the remaining undiked sections were never connected. Either the Vance Creek dike or preexisting portions of the Skokomish River dike were also repaired in 1953.

Sediment on bars of the Skokomish River and Vance Creek was removed in 1954, possibly in the vicinity of the previous year's diking projects. According to valley residents, efforts were usually concentrated on the river bank opposite the eroding bank. Work to stabilize the actual eroding bank may not have been conducted, or was not included in the cost-share projects.

The last cost-share project through the state's flood control participation program was a rock revetment placed on the Skokomish River in June 1973. This project may have been maintenance on the dikes previously constructed along the mainstem.

State Flood Control Zone Permits

Records back to 1956 show that a significant number of private projects were initiated on not only the Skokomish River and Vance Creek, but also on smaller tributaries, such as Swift Creek, Purdy Creek, Hunter Creek, Weaver Creek, and unnamed tributaries or historic side-channels on the northerly side of the Skokomish River. Information is not available on project costs to determine the scale of activity. Flood control permits are summarized in Appendix P.

The majority of the projects involved bank revetment or riprap placement. Road and bridge maintenance and dike construction increased, while sediment removal from river bars and debris removal continued. It is assumed that the SCS or the local conservation district provided technical assistance to most of these streambank protection projects on an advisory basis. Design and construction standards were not established as part of the state flood control zone permit program; therefore, there were no consistent requirements to be enforced by the state. Project planning and design was, therefore, primarily the result of private initiative and any technical assistance provided by SCS or the conservation district.

Ecology suspended the issuance of flood control zone permits was suspended in 1976 pending the development of a comprehensive river basin flood plain management plan and Ecology approval of the plan. A plan was submitted to Ecology in 1984, but was incomplete and was not approved.

Hydraulic Project Approval Records

Flood control related projects approved by WDFW through their Hydraulic Project Approval (HPA) permit program are summarized in Appendix Q, and discussed below.

Bank Revetment and Riprap Projects

The South Fork of the Skokomish River has been the area of concentration for most bank revetment and riprap projects. Almost half of all recent HPAs issued for private bank stabilization on the Skokomish River have been for the area just upstream of the confluence with the North Fork. Cabled tree or log revetments were often used in preference to boulder riprap, which is not locally available.

The mainstem of the Skokomish River and various Skokomish Valley creeks have received a well-distributed attention in the area downstream from the North Fork confluence on the west side of US 101, including three projects by Mason County and one by each of the Skokomish Valley FCZD, the Washington State Department of Transportation (WSDOT), and WDFW. The bank stabilization projects constructed by Mason County and the Skokomish Valley FCZD were placed on private land with the owners permission. Three other projects were privately constructed within a 2-mile reach east or downstream of the Skokomish Community Church.

Roads and Bridges

Mason County constructed a bridge over Hunter Creek in 1956. It is not known what had been in place previously, but it can be assumed that the bridge was built to better avoid potential flood damage and sheet flooding, which would limit access during high flows. No historic records of work done on county roads within the Skokomish Valley are available to assess historic flood damages or flood-related maintenance. No road plan or construction effort has been made to elevate the roadway above the elevation of annual flooding. As noted in Chapter 3, the construction of Skokomish Valley Road and Bourgault Road West along public land survey lines on the valley floor, crossing the many side-channels of the original river system, exposes these primary transportation and evacuation routes to flooding on an annual basis.

Vance Creek was reportedly diverted by a major landslide during the early 1950s, necessitating construction of a new bridge at the present location. The Swift Creek bridge is known locally as the Old Vance Creek bridge.

Other road work included a revetment placed along Purdy Creek Road in 1962 by Mason County. The US 101 bridge and culvert over Hunter Creek were replaced by the Washington Department of Highways (now WSDOT) in 1969. SR 106 required riprap revetment along mainstem RM 1 in 1975 due to channel change and erosion. In 1983, WSDOT replaced a bridge over an unnamed side-channel on the northern side of the Skokomish mainstem. Local residents and historic records indicate that this side-channel was previously the mainstem channel. The capacity of this channel has been reduced over time by filling for residential purposes. Also in 1983, Mason County received an HPA to replace a culvert on Weaver Creek with a bridge. The same year, a private bridge was constructed over Weaver Creek. The Vance Creek Bridge, in the upper valley, was repaired and, due to channel erosion, was replaced in 1986-1987 with a significantly floodproofed new bridge. In 1986, WSDOT repaired the bridge over Purdy Creek and began

replacement of the SR 106 bridge. Although the SR 106 bridge was not damaged by flooding, it will be elevated to accommodate flooding.

Substantial maintenance has been carried out over the years on all roads, and particularly water crossings, within the Skokomish River floodplain. If flooding continues to increase in rate and severity due to river bed aggradation, the need for road and bridge maintenance and replacement will become more regular and extensive.

Sediment and Debris Removal

Debris and gravel removal projects have been carried out by private individuals and by WDFW in Vance, Weaver, Hunter, and Purdy Creeks, and the South Fork and mainstem of the Skokomish River.

HISTORICAL FLOOD DAMAGES

Information on damage cost estimates is scant, and based on numerous information sources. What is known of flood damage costs from the best available sources is summarized in Table 4-2.

TABLE 4-2.
ESTIMATED FLOOD DAMAGE COSTS IN THE SKOKOMISH VALLEY

Year	Flood Damage ($)	Year	Flood Damage ($)	Year	Flood Damage ($)
1926	13,400	1935	13,400	1959	56,000
1927	13,400	1936	13,400	1961	114,000
1928	13,400	1937	13,400	1962	1,218
1929	13,400	1938	13,400	1964	31,486
1930	13,400	1939	13,400	1972	no data
1931	13,400	1940	13,400	1972	no data
1932	13,400	1941	13,400	1974	20,652
1933	56,600	1955	125,000	1975	6,924
1934	13,400	1959	71,000	1986	110,000

SOURCE: Ecology 1988

Chronic Problem Areas

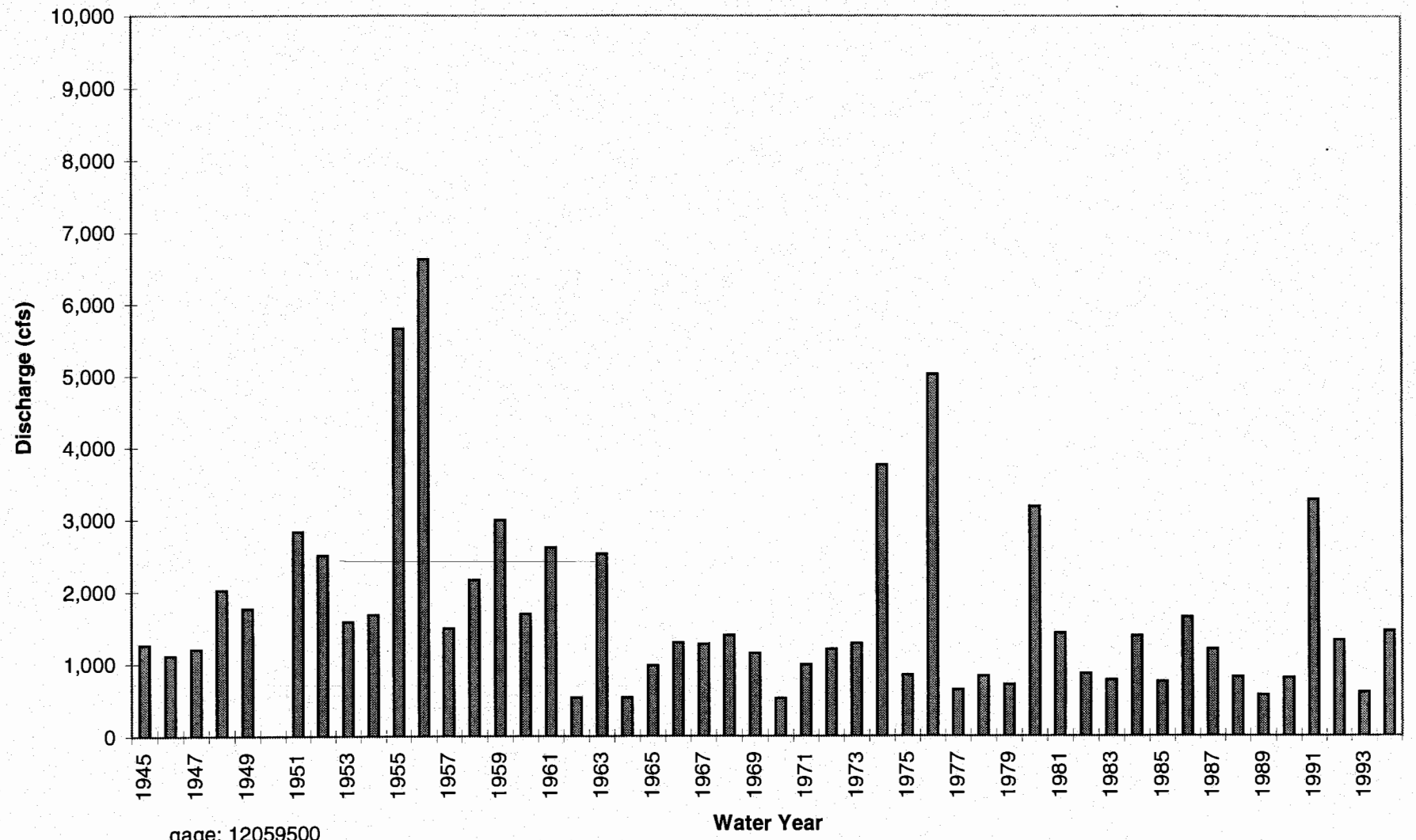
- The pattern of discontinuous diking along the mainstem (see Figure 4-1) has mitigated the problem of chronic low-level flooding in some areas of the Skokomish Valley, but has concentrated flooding onto unprotected areas where the higher flow velocities create the potential for gully erosion and other flow-related damage that did not exist prior to dike construction.
- Soil erosion is a problem for operators of Christmas tree plantations who use clean-cropping methods (not maintaining groundcover). Plantations with ground cover show no signs of soil loss. Clean-cropped plantations show

signs of both sheet and gully erosion. Operators of clean-cropped plantations assert that clean-cropping is necessary to achieve rapid growth of Christmas trees for an adequate return on investment.

- Roadways covered by flood waters impede or prevent travel by Valley residents. People who live in low-lying areas often move their vehicles to higher ground when they receive adequate advance warning of flooding. This is a problem on the Skokomish Indian reservation and in the Valley from US 101 upstream to the vicinity of the Skokomish Community Church.
- Structures, both residential and agricultural, are subject to water damage, which occasionally includes structural damage. The contents of the structures, such as home furnishings, appliances, and farm machinery, may also be damaged. Few Valley residents have elevated their homes to a level adequate to protect against substantial flooding.
- Agricultural fencing may be damaged by debris carried by flood waters, and fields may be littered by stranded debris.
- Sewage disposal throughout the Valley is by onsite drain fields. Under normal conditions a high water table makes drain fields marginally effective. Sewage disposal drain fields are nonfunctional during floods and for days to weeks thereafter.
- The South Fork and mainstem from South Fork RM 3 downstream to about mainstem RM 5.5 are aggrading. A secondary effects of aggradation is generalized streambank erosion, which is notably severe in certain locations, including the following:
  - At South Fork RM 1.8, bank erosion has cut to within 50 feet of Skokomish Valley Road, and threatens to undermine the roadway within a few years.
  - An eroding right bank between RM 8.1 and 8.3 in the vicinity of Skokomish Community Church has cut to within 50 to 70 feet of Skokomish Valley Road.
  - An eroding left bank at RM 3.5 affects Skokomish tribal trust land. The cause of the erosion may due to the normal meandering process, or may be aggravated by streambank protection projects carried out upstream over the years.

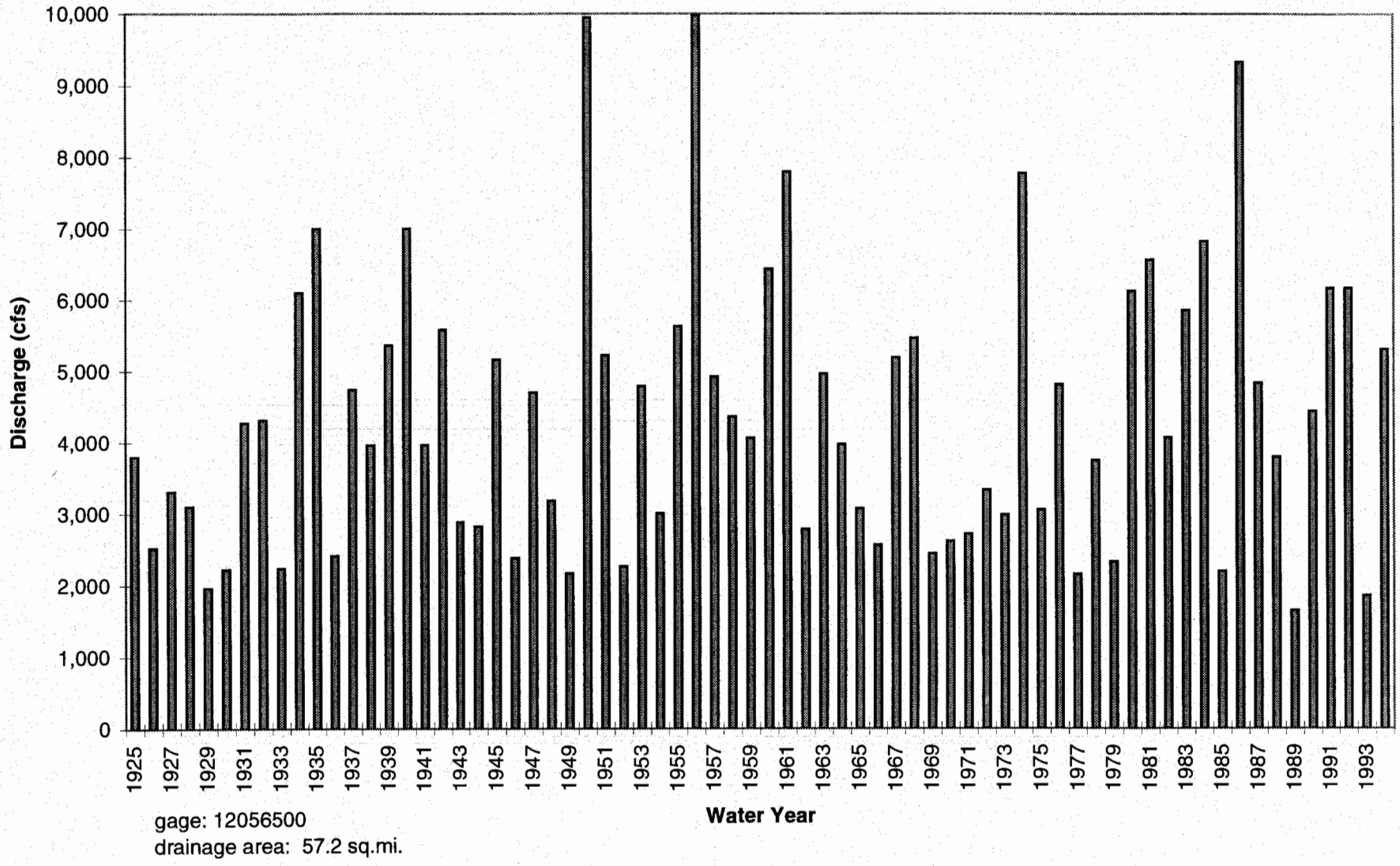
Historical Floodflows

Figures 4-2 through 4-5 show the annual maximum of the daily average discharges for two gauging stations on the North Fork, one on the South Fork, and one on the mainstem. Similar figures for other gauging stations are included in Appendix R. A comparison of Figures 4-2 and 4-3 indicates that the Cushman Project has consistently provided flood control benefits. For the common period 1945-1994, the average of the values at the North Fork station above the Cushman Project, at Staircase Rapids, is 4,539 cfs, while the average of the values at the North Fork Station below the project, near Potlatch, is 1,692 cfs, the difference represents water diverted to Hood Canal.

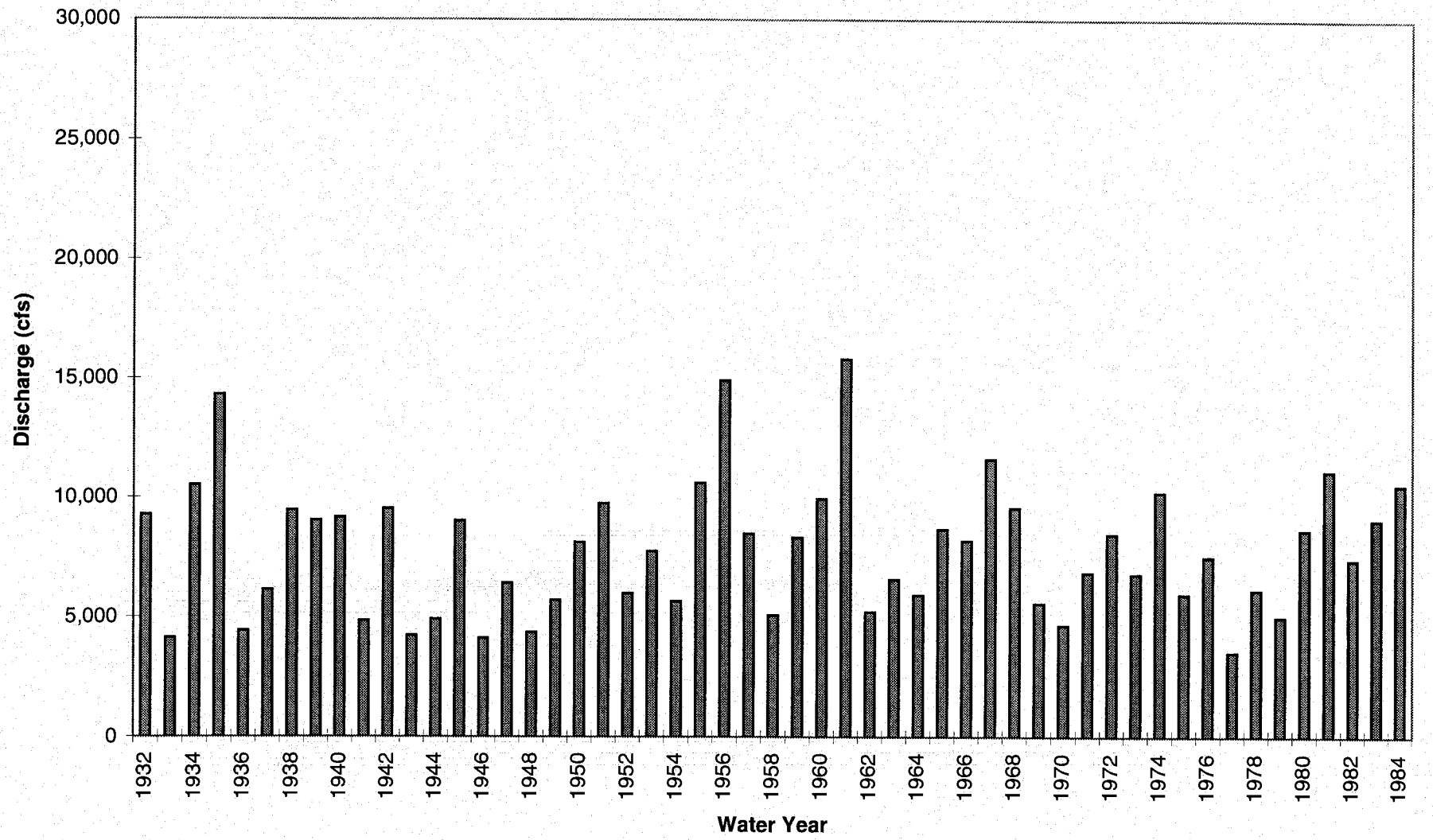


gage: 12059500
drainage area: 117 sq.mi. (includes 99 sq.mi. upstream of Cushman Dam No. 2, which is noncontributing except during spill)

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-2. MAXIMUM DAILY AVERAGE DISCHARGE, NORTH FORK SKOKOMISH RIVER NEAR POTLATCH

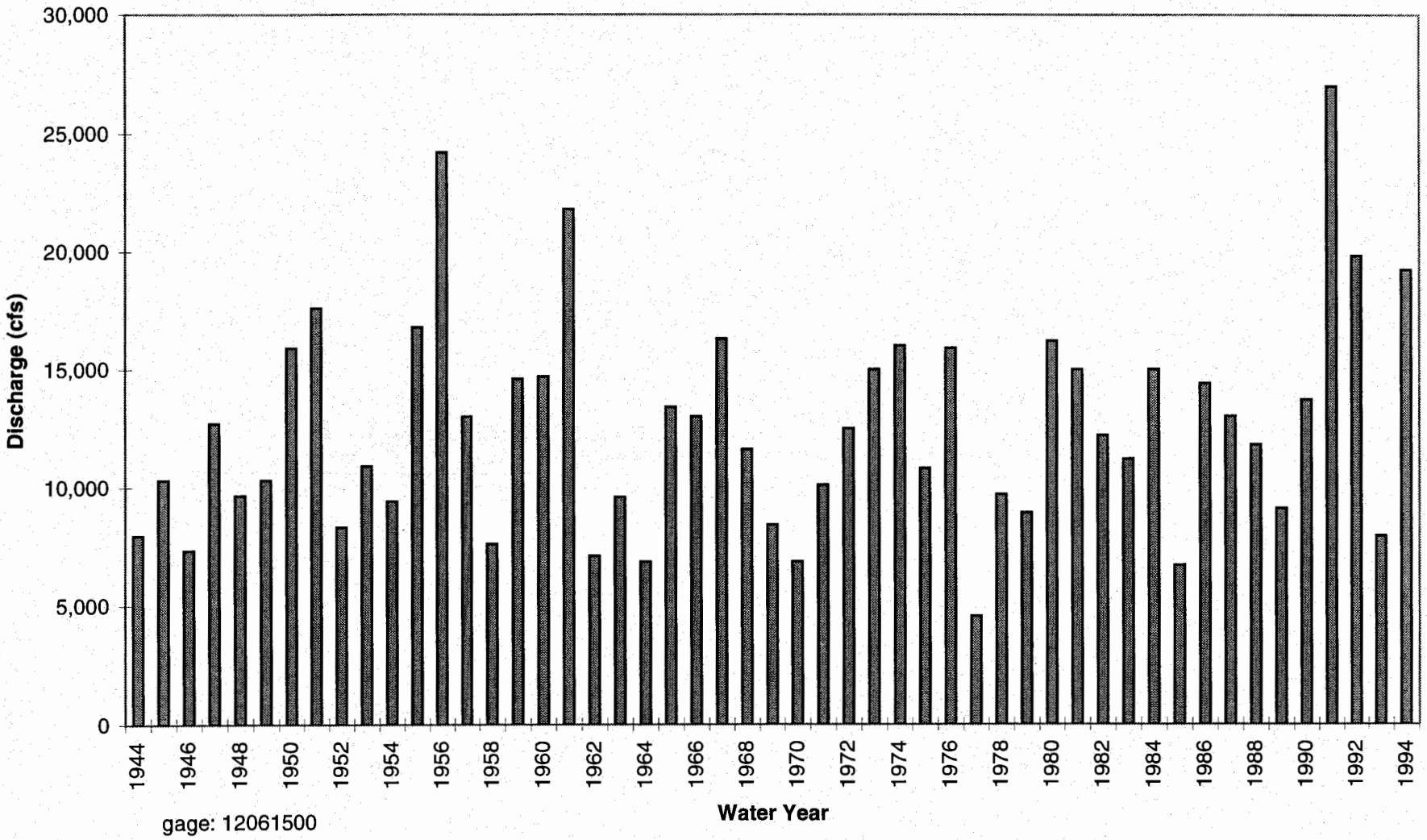


KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-3. MAXIMUM DAILY AVERAGE DISCHARGE, NORTH FORK SKOKOMISH RIVER BELOW STAIRCASE RAPIDS



gage: 12060500 (1932 - 1984 only)
drainage area: 76.3 sq.mi.

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-4. MAXIMUM DAILY AVERAGE DISCHARGE, SOUTH FORK SKOKOMISH RIVER NEAR UNION



gage: 12061500
drainage area: 227 sq.mi. (includes 99 sq.mi. upstream of Cushman Dam No. 2, which is noncontributing except during spill)

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Mason County
SKOKOMISH RIVER COMPREHENSIVE
FLOOD HAZARD MANAGEMENT PLAN

Figure 4-5.
MAXIMUM DAILY AVERAGE DISCHARGE,
MAIN STEM SKOKOMISH RIVER NEAR POTLATCH

Since the flows are presented in Figures 4-2 through 4-5 are the average daily flows, the peak flow are higher. USGS records indicate that the second and third largest recorded maximum discharges at the Skokomish River near the Potlatch gauge occurred on November 23, 1990, and November 3, 1955. Maximum discharges recorded during these floods were 36,600 cfs (gauge height 16.80) and 27,000 cfs (gauge height 12.6 for site and datum then in use). The largest flood event of record occurred in December 1994, summarized below.

December 1994 Flood

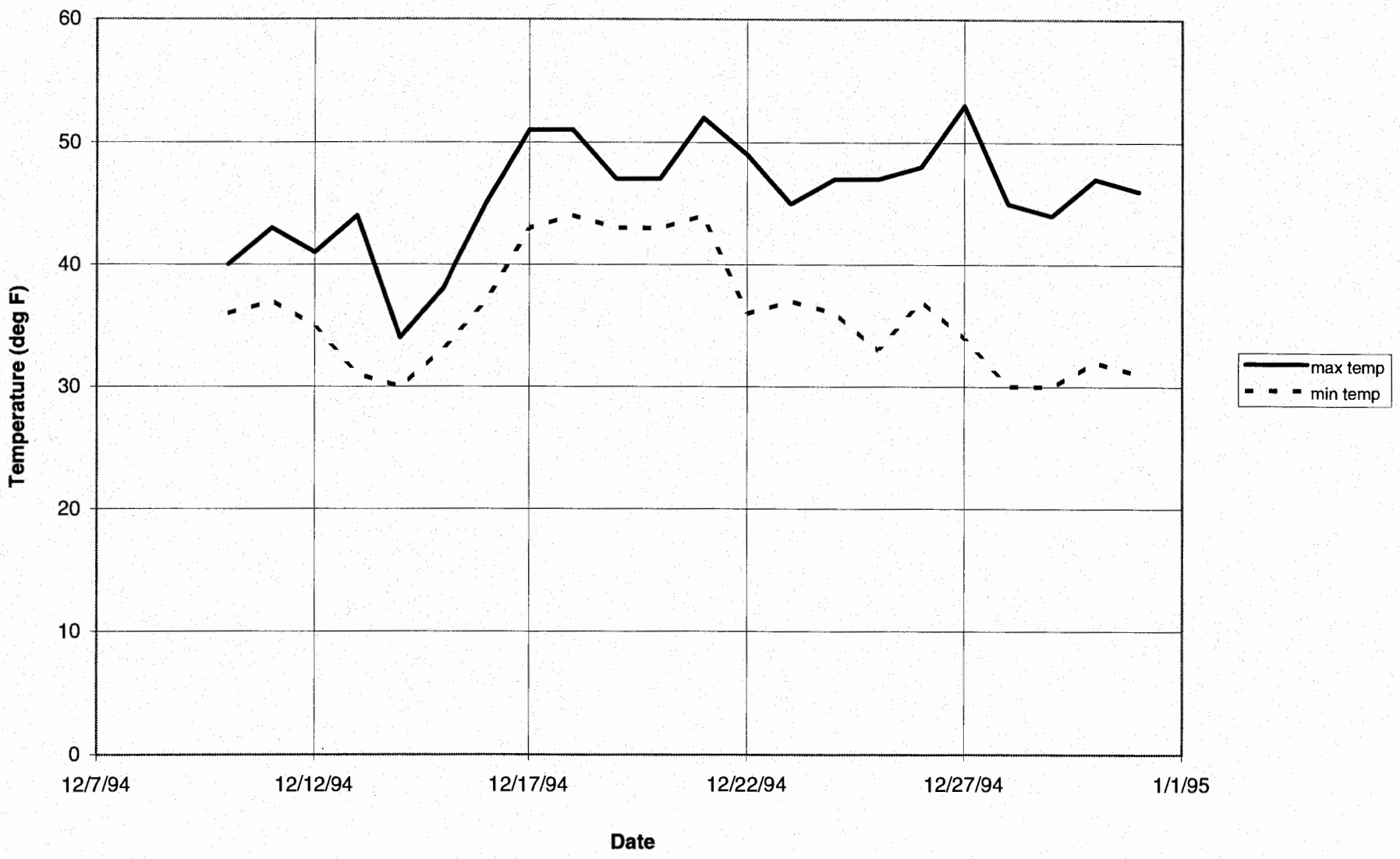
The largest flood on record in the Skokomish Valley occurred in December 1994. A summary of the climatic conditions is shown in Figures 4-6 and 4-7. Data are from the Cushman Powerhouse 2, at an elevation of 20 feet above sea level. As seen in Figure 4-6, a warming trend occurred between the 10th and the 17th of that month. A total of 23.1 inches of precipitation fell at the Cushman Powerhouse between those dates. The maximum daily precipitation for the period, 6.20 inches, occurred on December 20.

Two discharge peaks occurred during the December event, as indicated by USGS 15 minute flow data from the mainstem Skokomish at Potlatch gauge (see Figure 4-8) The first, larger peak occurred some time between 10:00 PM on December 19 and 11:30 AM on December 20. The peak gauge height recorded in this period was 17.91 feet. However, due to the limited accuracy of the rating curve used to determine discharge from stage data, the exact discharge associated with that stage is unknown; this stage is in fact off the rating curve. The largest stage and associated discharge on the curve are 16.7 feet and 32,500 cfs, respectively. Based on the FEMA flood frequency graph, a flow of 32,500 cfs is between a 50- and 100-year event.

The second largest discharge peak occurred on December 27, at 3:45 PM. The discharge recorded at this time was 25,500 cfs.

TPU prepared a summary of the role of the Cushman Project during the flood events in response to local concern over the effect of the project on flooding. Hydrographs from this summary are presented in Figures 4-9 and 4-10. (Note that the peak flow indicated for the December 20 event was extrapolated based on the data described above. The summary concludes that

> The Cushman Dam played a positive role in reducing the magnitude of downstream flooding. The dam allowed Lake Cushman to act as a storage reservoir; retaining flood waters while releasing very minimal downstream flows. To clarify this point it should be noted that during the storm event, flow into the lake reached an estimated 19,700 cfs while the release from the Cushman No. 2 Dam during this period was only 35 cfs (as mandated by the Washington State Department of Ecology). During late December, the level of Lake Cushman rose 15.9 feet, which equates to over 19 billion gallons of water stored.
>
> The flows released from the Cushman No. 2 Dam are recorded by the USGS gauge (ID # 120588) located on the North Fork of the Skokomish River downstream of the Cushman project. The peak flow recorded by the gage was 87 cfs; 35 cfs was from Cushman No. 2 while the remaining 52 cfs was most likely from local runoff and direct precipitation.



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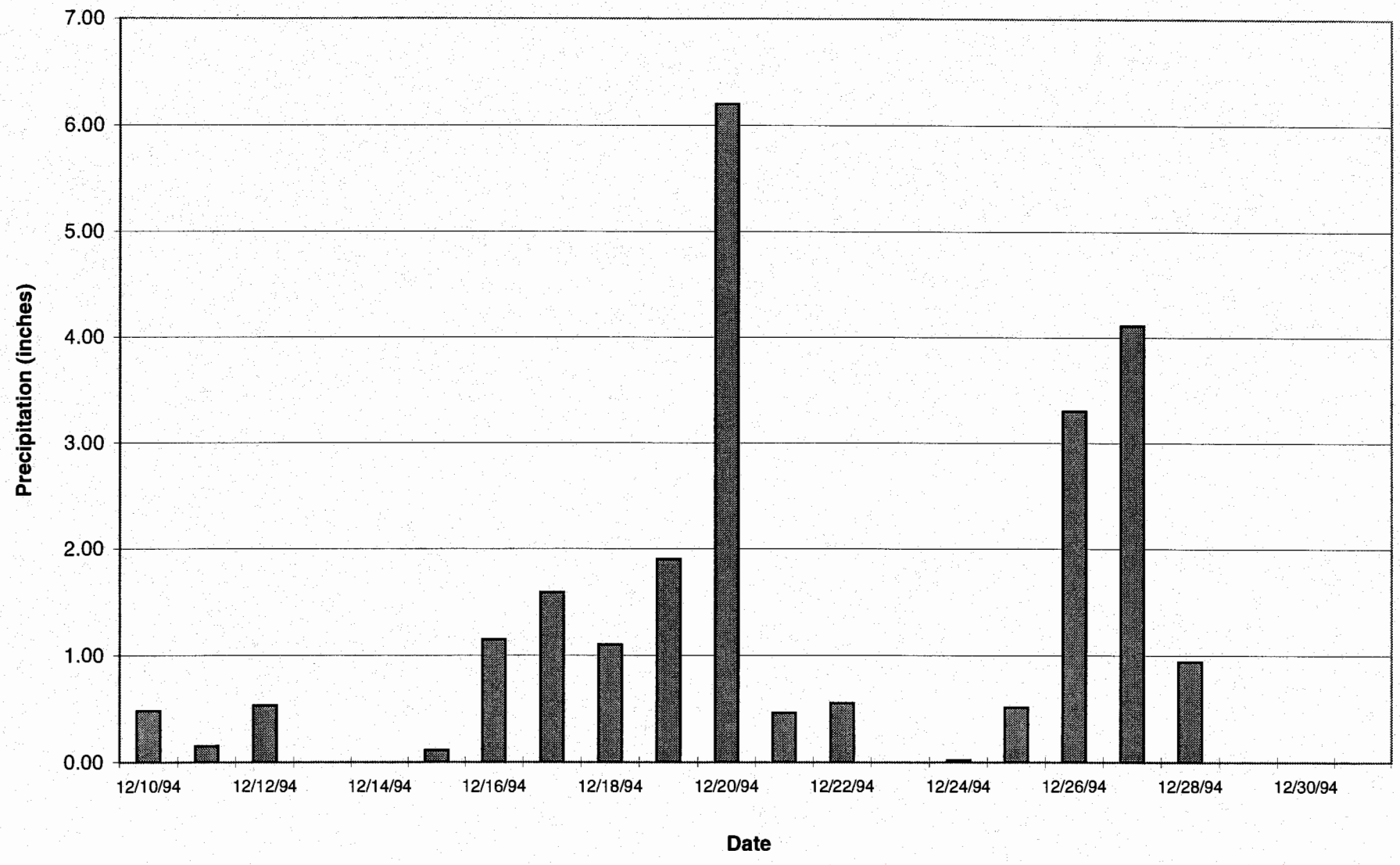
SKOKOMISH RIVER COMPREHENSIVE
FLOOD HAZARD MANAGEMENT PLAN

Figure 4-6.
DAILY TEMPERATURE AT CUSHMAN POWERHOUSE 2



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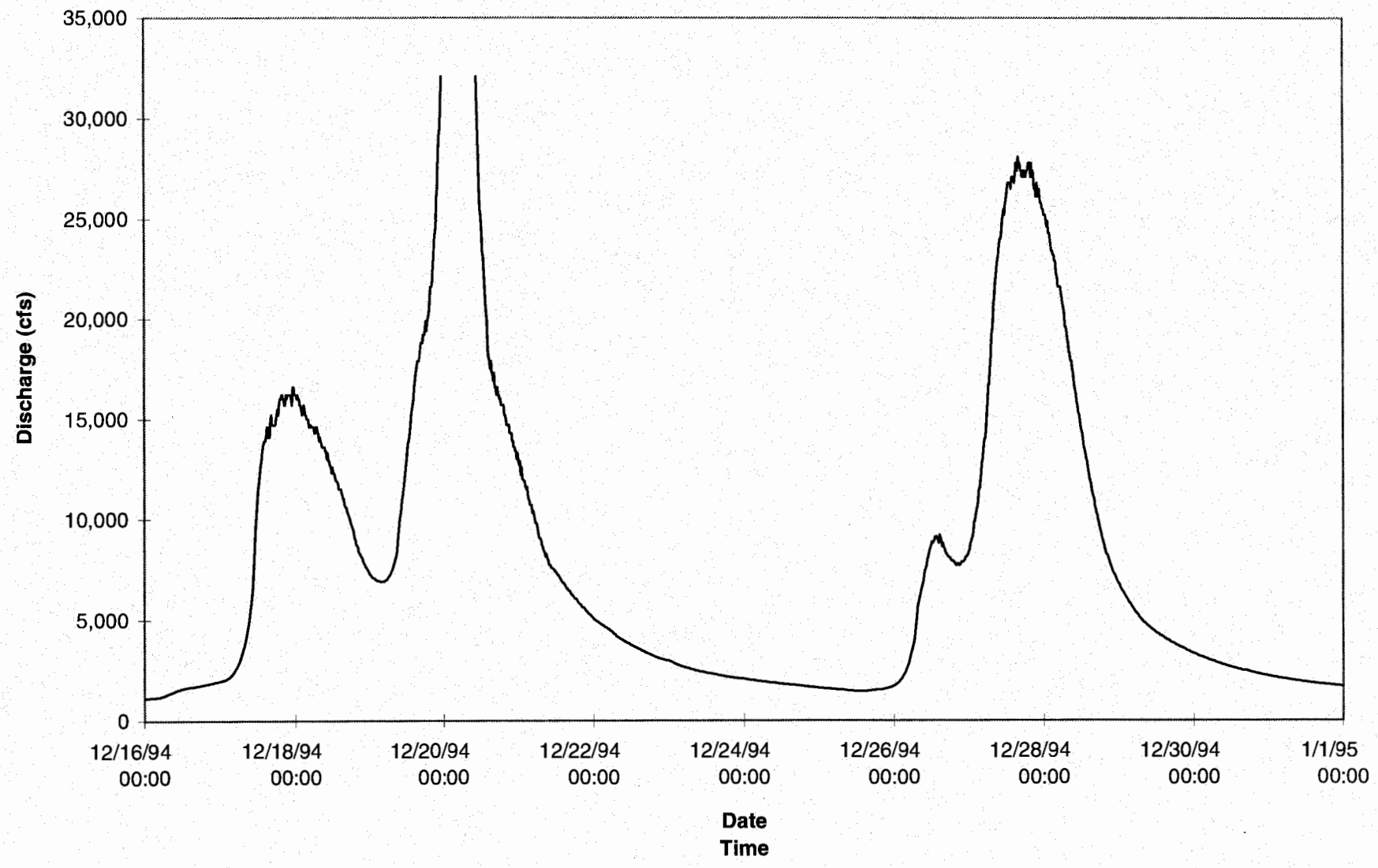
FLOOD HAZARD MANAGEMENT PLAN

Figure 4-7.
DAILY PRECIPITATION AT CUSHMAN POWERHOUSE 2



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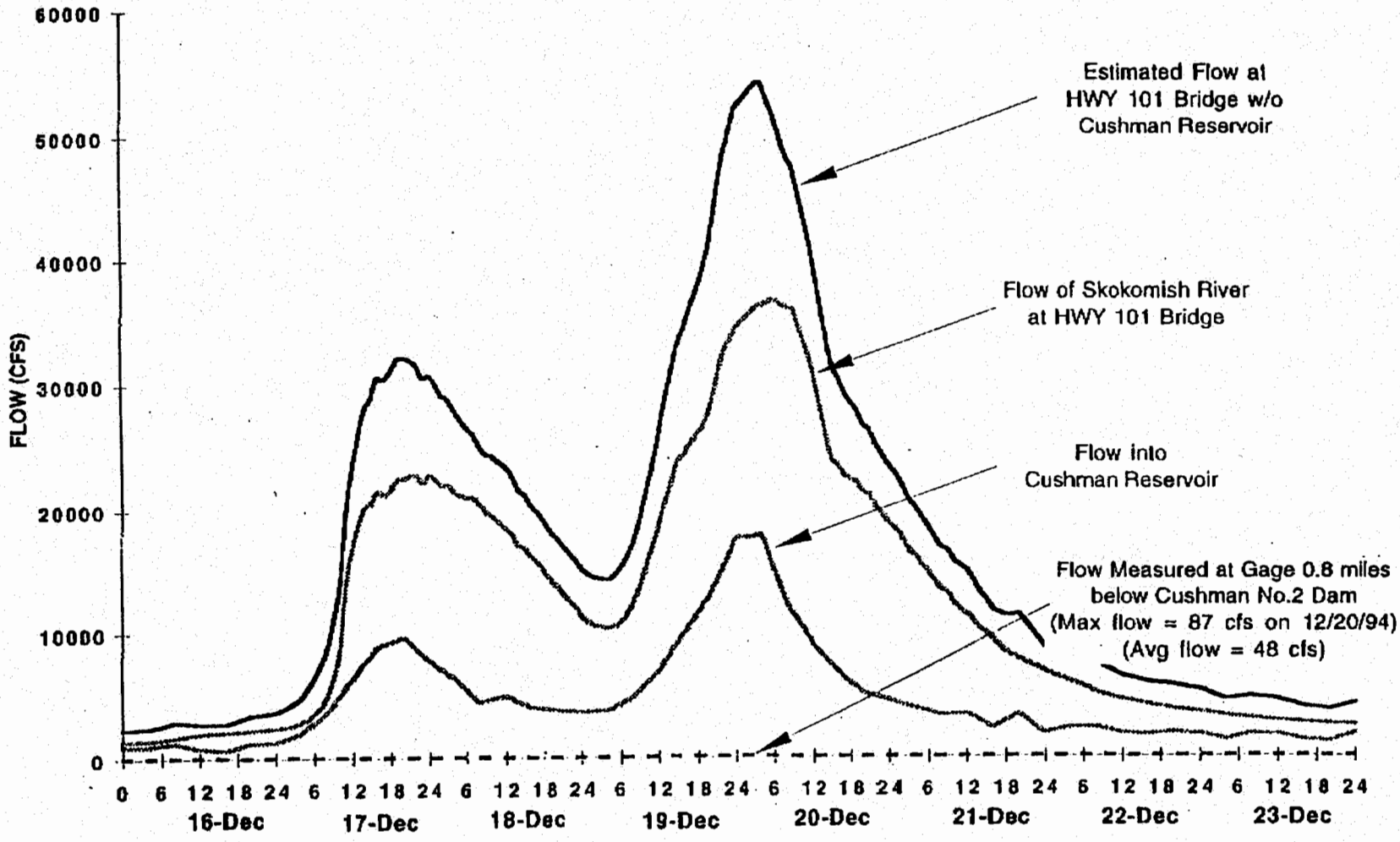
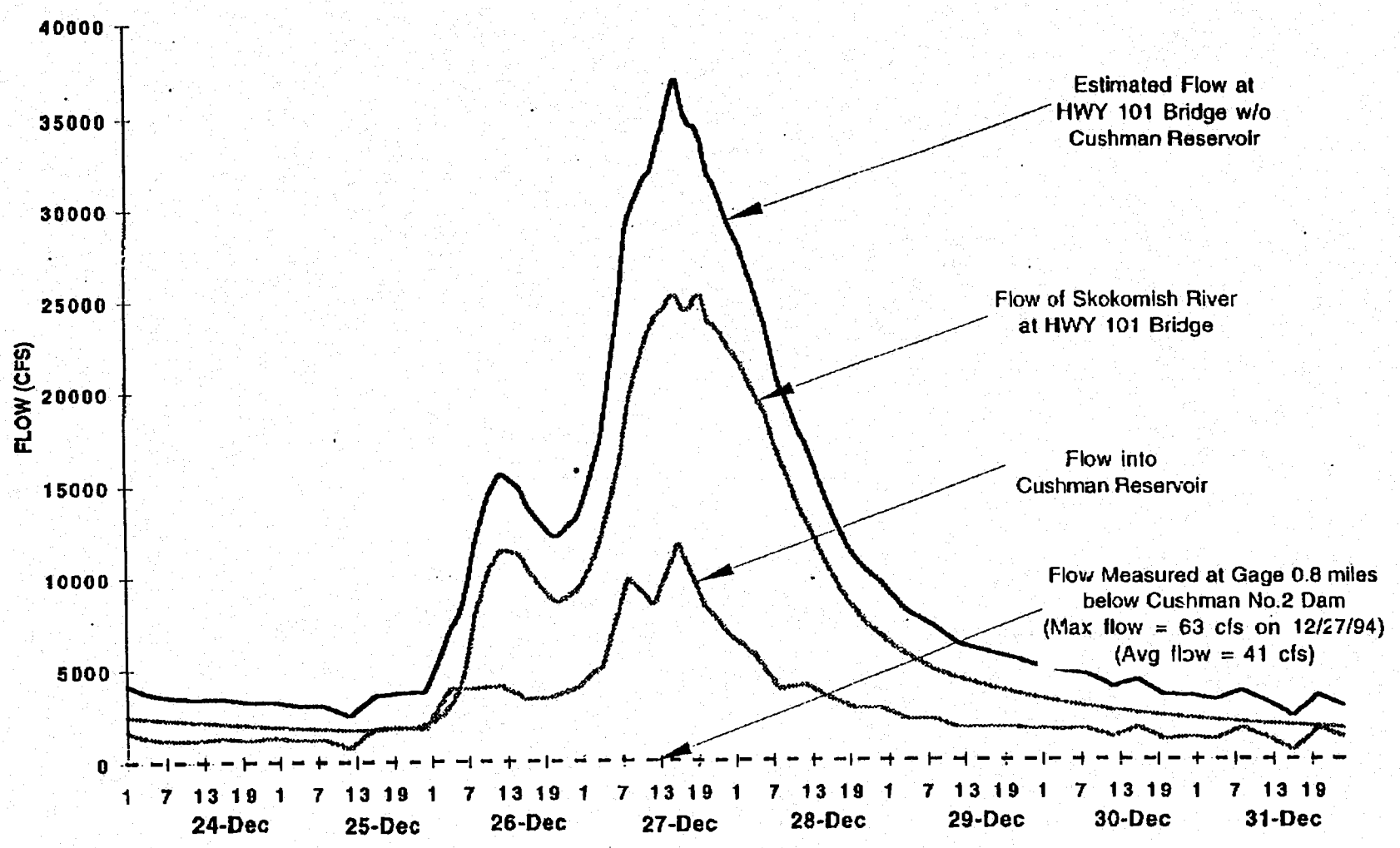
SKOKOMISH RIVER COMPREHENSIVE
FLOOD HAZARD MANAGEMENT PLAN

Figure 4-8.
15-MINUTE DISCHARGE,
MAIN STEM SKOKOMISH RIVER AT POTLATCH



SOURCE: Klein, Steven J. January 11, 1995 letter to Evan Tozier

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-9. REDUCTION IN FLOOD MAGNITUDE DUE TO THE OPERATION OF THE CUSHMAN PROJECT, DECEMBER 16-23, 1994



SOURCE: Klein, Steven J. January 11, 1995 letter to Evan Tozier

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 4-10. REDUCTION IN FLOOD MAGNITUDE DUE TO THE OPERATION OF THE CUSHMAN PROJECT, DECEMBER 24-31, 1994

> The attached graphs shows the flows measured near the Highway 101 bridge, the calculated flow into Lake Cushman, and the flows that would have resulted without the flood control capability of the Cushman project. The Cushman project reduced the magnitude of the Skokomish Valley flooding by nearly 20,000 cfs. Without the flood control benefits of the Cushman project, flood waters would have been 60% higher (Klein, S., 11 January 1995, personal communication).

Damage due to flooding of structures and property was widespread throughout the Valley. The Shelton-Mason County Journal described the timing of the floods and the damage:

> Melting snow, heavy rain, and a rising tide this week contributed to the biggest flood of the Skokomish River Valley in recent memory. As the rain stopped on Tuesday, the waters started to recede, leaving behind torn roads, battered bridges, silt filled homes and stranded fish as the legacies of the worst of three floods that have struck the valley this fall. The biggest headache was at the Purdy Creek Bridge, where state engineers were trying to figure out a way to reopen Highway 101.
>
> According to the National Weather Service, the flood reached its high-water mark at 5 A.M. on Tuesday morning, when the water of the Skokomish River crested at 17.5 feet, about 2.5 feet above flood stage. By 1:45 P.M. on Wednesday, the river had dropped to 15.6 feet, which was still a half-foot above the official flood stage.
>
> The result was a hectic Tuesday for state and county road crews. Highways 101 and 106, as well as several smaller roads, were closed to through traffic by standing water and mudslides. The Mason County Public Works Department had about 30 people on the road clearing away debris and trying to unplug culverts.
>
> The Mason County Department of Emergency Services set up a command post by the Purdy Creek bridge. Using their own jet-boat and a hovercraft on loan from Pierce County, the sheriff's deputies evacuated about 50 people stuck in their houses along Skokomish Valley Road (Shelton-Mason County Journal, December 24, 1994).
>
> Flood waters surged again on Tuesday as another heavy rain cause the Skokomish River to overflow its banks for the third time this month...The third flood started at about 9 A.M. on Monday and crested at 16.5 feet at about 4 P.M. on Tuesday. The river has been falling slowly ever since. By 10 A.M. on Wednesday it was down to 16.0 feet, still a foot above the official flood stage.
>
> Some of the costs have already been identified. Clarissa Lundeen of the Washington Department of Transportation said the DOT has already spent about $400,000 dealing with the local effects of the flood. The biggest tab is for work to repair Highway 101 near Purdy Creek, where last week's rising waters ripped huge chunks of asphalt off the shoulder of the road and deposited them in the thoroughfare (Shelton-Mason County Journal, December 29, 1994).
>
> Jerry Hauth, Mason County's director of public works, estimated Wednesday that the county will have to spend between $250,000 and $500,000 to fix up roads and bridges damaged by flooding that occurred between December 17 and 29, when heavy rain caused asphalt to buckle and crack from Shelton to Belfair and from Pickering to Hoodsport (Shelton-Mason County Journal, January 5, 1995).

Theoretical Flood Flows

According to FEMA, the peak discharge at the US 101 bridge for a 100-year event would be 34,910 cubic feet per second (cfs). The peak discharge at the same location for a 10-year event would be 24,750 cfs (FEMA 1988). The aerial photographs in Figures 4-11a and 4-11b show the 1987 flood, when a daily flow of 11,900 cfs was recorded at US 101; this is less than the flow of the 2-year event (16,200 cfs). A further discussion of these theoretical flows and how they relate to the flood of 1994 is presented in Chapter 6.

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Mason County
COMPREHENSIVE FLOOD HAZARD
MANAGEMENT PLAN

Figure 4-11a.
1987 FLOOD AERIAL PHOTOS

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Mason County
COMPREHENSIVE FLOOD HAZARD
MANAGEMENT PLAN

Figure 4-11b.
1987 FLOOD AERIAL PHOTOS

CHAPTER 5.
REGULATORY SETTING

INTRODUCTION

This chapter provides a summary of the regulatory requirements for development activities undertaken within the Skokomish River basin. The regulations and policies identified here guide, and in some cases limit, activities in the basin. Regulatory authority over the Skokomish River basin consists of overlapping jurisdictions by federal, state, and local agencies. Permission to engage in development actions within the basin, particularly within the defined floodway, will typically involve more than one agency. Interrelationships between the various agencies and the permit process are described in this chapter.

A separate section at the end of the chapter describes regulatory programs and approaches that can be used for property buyouts, relocation, or floodproofing. These types of flood hazard management approaches are appropriate for properties associated with repetitive losses. Repetitive losses result from recurring damage to property as a result of location of the property or condition of the structure. This issue and alternatives to address it, including property buyouts, relocation, and floodproofing, are discussed in more detail in Chapter 6.

AGENCIES AND REGULATIONS

Growth Management Act

In April 1990, the State Legislature enacted House Bill 2929, the Growth Management Act (GMA), to provide a framework for managing development in the state's faster growing counties. Either of the following conditions require that counties and the cities within them plan under GMA:

- The County has a population of 50,000 people or more and has experienced a population increase of at least 10 percent in the previous 10 years.
- The County, regardless of current population, has experienced a population increase of over 20 percent in the previous 10 years.

Mason County falls in the second category, and is required to develop and adopt an updated comprehensive plan. It is anticipated that the plan will be adopted in spring 1996. In addition, the County must update its development regulations, such as zoning and shoreline management, to implement the County's comprehensive plan.

The State Department of Community, Trade, and Economic Development (CTED) is responsible for administering the Growth Management Act. The Act contains 13 broad goals for comprehensive plans and development regulations (Part 1, Section 2 of the GMA). The goals related to surface water issues in the Skokomish River basin include the following:

- Encourage the retention of open space and development of recreational opportunities; conserve fish and wildlife habitat; increase access to natural resource lands; develop parks

- Maintain and enhance natural resource-based industries, including productive timber, agriculture, and fisheries industries. Encourage the conservation of productive forests and productive agricultural lands, and discourage incompatible uses
- Protect the environment and enhance the state's high quality of life, including air and water quality and the availability of water.

To ensure that GMA goals are met, each comprehensive plan must contain five plan elements: land use, housing, transportation, capital facilities, and utilities (Part 1, Section 7 of the GMA). The required land use element has particular relevance to the Skokomish River basin. Besides designating the proposed general distribution, location, and extent of uses of land, it must also provide for the protection of the quality and quantity of groundwater used for public water supplies and review drainage, flooding, and stormwater runoff patterns to provide guidance for corrective actions to mitigate or cleanse discharges that pollute waters of the state.

Local governments are also required to classify and designate "resource lands of long-term commercial significance" and "critical areas." Resource lands include areas of agricultural, forest, and mineral resources. Critical areas include wetlands, fish and wildlife habitats, aquifer recharge areas, frequently flooded areas, and geologically hazardous areas. Mason County is in the process of developing a Resource Conservation and Critical Areas Protection ordinance to meet GMA requirements. This ordinance will deal in part with the conditions found in the Skokomish River basin.

The Growth Management Act does not require any special permits or review of individual projects. It is included in this chapter since the requirements of the GMA will likely result in changes to County development ordinances, some of which may have direct bearing on individual actions within the basin. Since the GMA is specific about dealing with surface water and flood control issues in the formation of a comprehensive plan, this CFHMP will provide the basis for formulating flood control goals and policies in the County's updated comprehensive plan. This relationship is illustrated schematically in Figure 5-1.

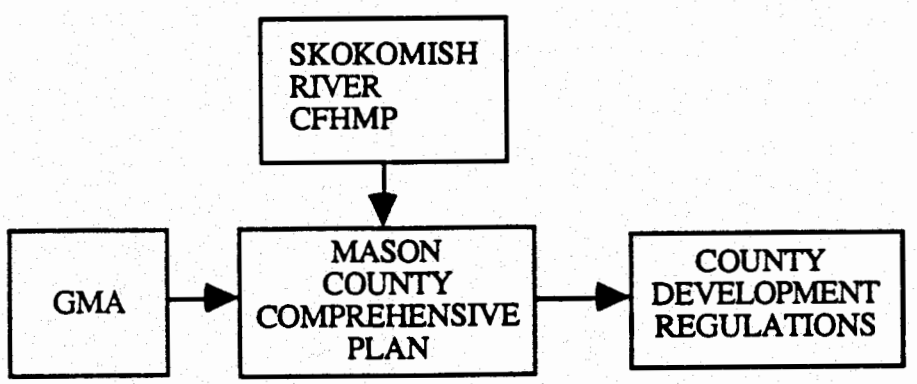


Figure 5-1.
RELATIONSHIP BETWEEN PLANNING DOCUMENTS AND DEVELOPMENT

State Environmental Policy Act (SEPA) Chapter 43.21C RCW

The State Environmental Policy Act was passed by the Legislature to ensure that the physical environmental is considered in the development decision of government officials. SEPA policies and goals apply to all levels of government in the state except the judiciary and the State Legislature. Ecology is the agency responsible for conducting the environmental review of projects and non-project actions that fall under SEPA provisions. The most recent implementing rules (WAC 197-11) were adopted by Ecology in 1990.

The purposes of SEPA are

> (1) To declare a state policy which will encourage productive and enjoyable harmony between man and his environment; (2) to promote efforts which will prevent or eliminate damage to the environment and biosphere; (3) and stimulate the health and welfare of man; and (4) to enrich the understanding of the ecological systems and natural resources important to the state and nation (RCW 43.21C.010 [1989]).

The SEPA process starts with an application to the County for a development action (building permit, grading permit, substantial development permit, etc.) or an agency-generated proposal. County staff then determine whether the requested action is exempt from SEPA review. A number of proposed actions are categorically exempt from the SEPA process and are referenced in WAC 197-11-800.

Categorical exemptions tend to be based on size. Exempted projects include most single-family homes, commercial buildings under 4,000 square feet, parking lots for 20 or fewer vehicles, and landfills or excavations of 100 cubic yards or less. Under SEPA rules, cities and counties are allowed to set their own size criteria within a specific range for the five categories of exemptions. Local criteria cannot be more restrictive than those of SEPA unless the location of the proposed action is in an environmentally sensitive area. If a project is determined to be exempt, then it is considered in compliance with SEPA.

For a non-exempt project, further consideration of the potential environmental impact is required. This begins with the applicant submitting an Environmental Checklist to the County's designated responsible official, who reviews the application and checklist and makes an environmental determination. The severity of the potential environmental impact will guide the responsible official's determination. If the proposed project is found to have no significant adverse environmental impact, then a Declaration of Non-Significance (DNS) is issued for the project. The responsible official may require that mitigation measures be incorporated into the project to offset minor impacts, in which case a Mitigated DNS (MDNS) is issued. If it is determined that the project has the potential for significant environmental impact, then a full and complete disclosure and analysis of the potential impacts is necessary, and the applicant is required to complete an Environmental Impact Statement (EIS).

Agencies may deny permits or other approvals under SEPA if the proposal would result in significant or adverse environmental impact and if mitigation measures would be insufficient to alleviate that impact. SEPA rules emphasize the identification of mitigation measures that may be required under SEPA as permit condition. Once the DNS or EIS is completed, the County may act upon the permit application or other approval required for the project.

Administrative or legal appeals concerning SEPA compliance must be linked to a specific government action (e.g., permit decisions) and be brought in a timely manner (WAC 197-11-680). Completion of the SEPA process is necessary before the County can act on the application and before any decisions can be made concerning other permit requirements, such as an HPA or Shoreline Substantial Development permit. Figure 5-2 illustrates the SEPA process.

Mason County Shoreline Master Program

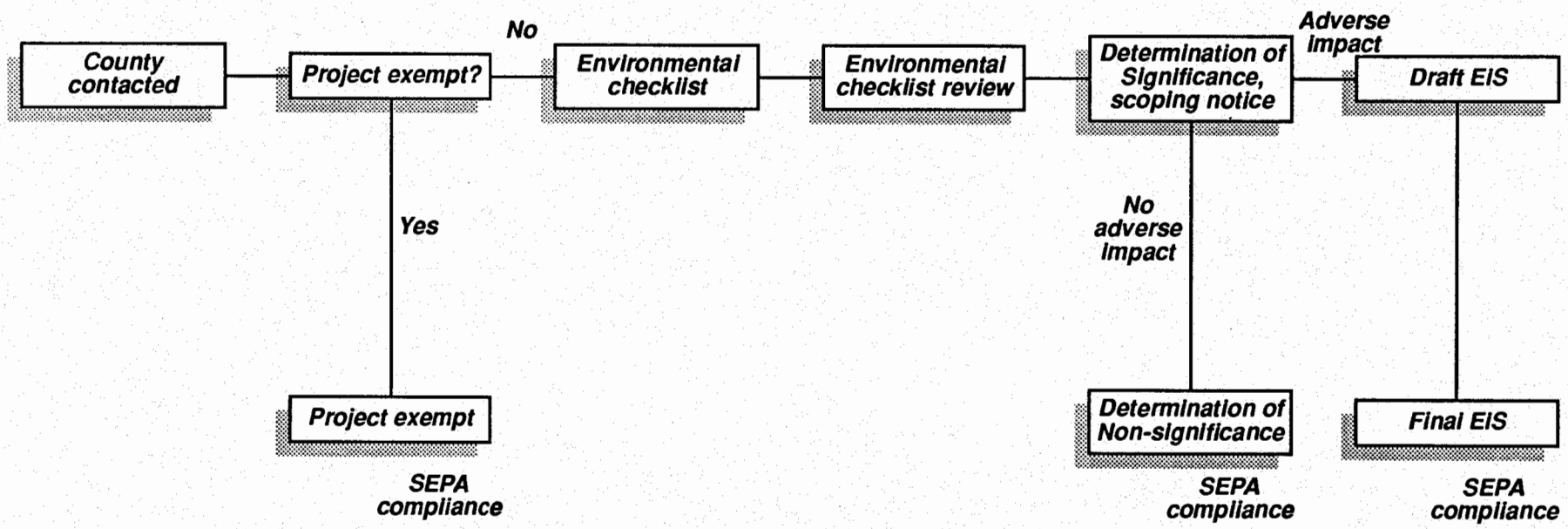
The Mason County Shoreline Master Program was adopted in August 1975 and amended in March 1988, in compliance with the Washington State Shoreline Management Act of 1971 (RCW 90.58). Along with the Flood Damage Prevention Ordinance and Title 16, Mason County Subdivision Regulations, of the County Code, the Shoreline Master Program (SMP) establishes regulations that control construction and land alteration in the Skokomish River basin.

Specifically, the SMP regulates development activities within 200 feet of a shoreline. Shorelines include all waters of the state and their associated wetlands, with the exception of those portions of streams that are upstream of the point where the annual mean flow is 20 cubic feet per second or less, and those lakes that are less than 20 acres in area (SMP p. 11). The Skokomish River is also designated as having Shorelines of Statewide Significance from the confluence of the North and South Forks to Hood Canal. This means that in developing policies and regulations the SMP must consider the following use criteria in order of preference:

- Recognize and protect statewide interest over local interest
- Preserve the natural character of the shoreline
- Consider long-term over short-term benefit
- Protect the resources and ecology of the shoreline
- Increase public access to publicly owned areas of the shoreline
- Increase recreational opportunities for the public in the shoreline
- Provide for other considerations when appropriate, including economic development, circulation, housing, a range of land uses adjacent to the shorelines, historic, cultural, and scientific considerations, and other considerations found to be appropriate or necessary.

Flood control projects would be "appropriate and necessary" under the last criterion.

Jurisdiction of the SMP also extends to associated wetlands, which are defined as lands extending landward 200 feet in all directions from the ordinary high water mark (OHWM) of a river, including the floodway and those portions of the floodplain that are within 200 feet of the floodway, and all marshes, bogs, swamps and deltas associated with the stream (SMP p. 13). Floodways are those land areas upon which flood waters are carried during periods of flooding that occur with reasonable regularity, although not necessarily every year. A floodway is generally identified by changes in surface soil conditions or changes in types or quality of vegetation. A floodway does not include those land areas that can reasonably be expected to be protected from flood waters by flood control devices (SMP p. 7). The definitions found in the SMP are the same as those used in the State Shorelines Management Act.



SOURCE: Washington State Department of Ecology Wetlands Section, "Wetlands Regulations Guidebook." 1988.

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Mason County
SKOKOMISH RIVER COMPREHENSIVE
FLOOD HAZARD MANAGEMENT PLAN

Figure 5-2.
PERMIT PROCESS
STATE ENVIRONMENTAL POLICY ACT

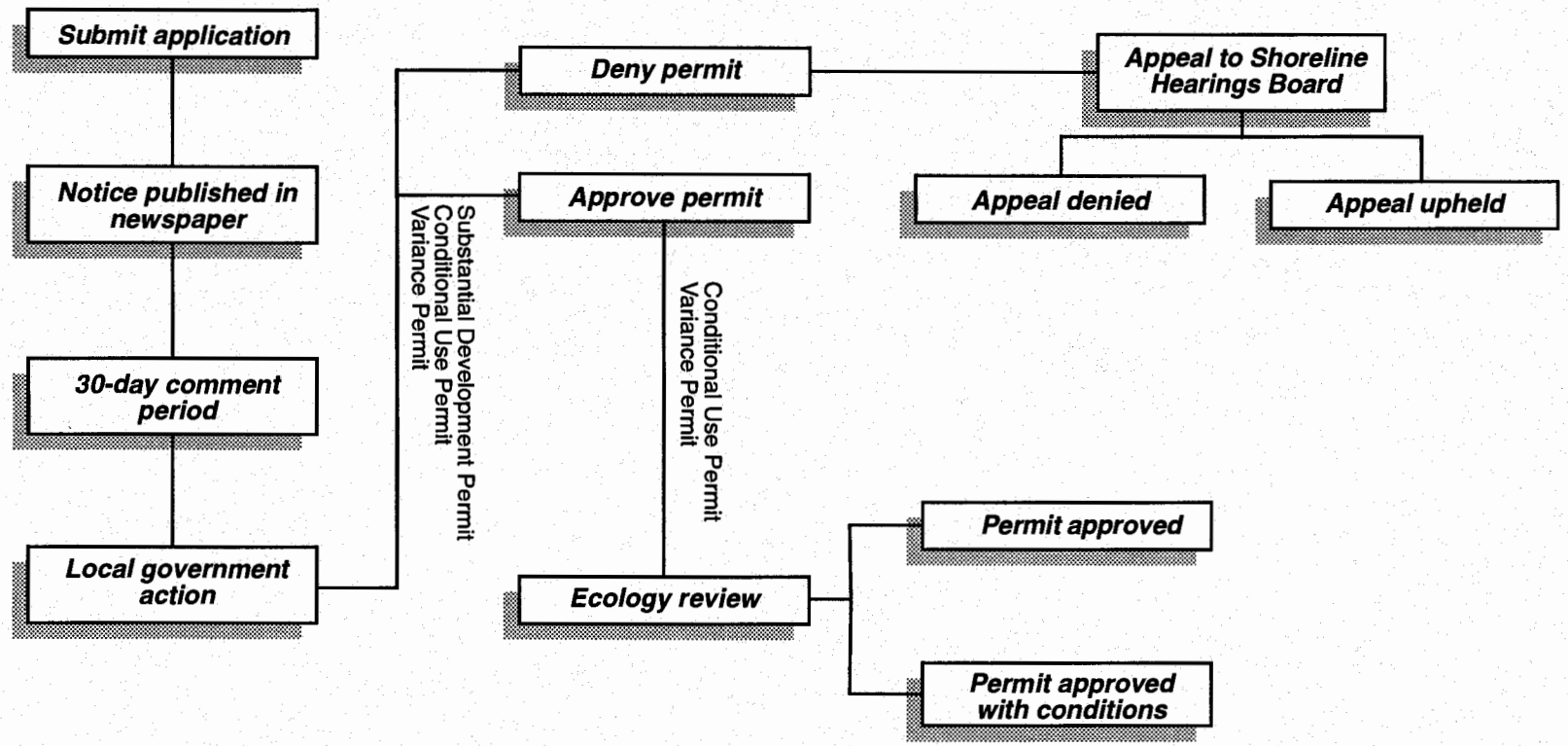
SMP regulations apply to land areas in the Skokomish River basin that are waterward of a line 200 feet from the edge of the floodway. They do not apply to portions of the floodplain more than 200 feet from the floodway. Creeks and streams flowing into the Skokomish River are regulated to the extent that they lie within the 200-foot shoreline jurisdictional boundary.

A substantial development or use of shorelines in the basin cannot be undertaken without first obtaining a Shoreline Development Permit (SDP). The SDP process is illustrated in Figure 5-3. Rules governing the application for an SDP are found in WAC 173-14. Under these rules, certain development activities are exempt from the SDP process, including normal maintenance and repair of existing structures, construction of residential bulkheads, emergency construction, construction of barns or similar agricultural structures on wetlands, construction of a single-family residence on a wetland, construction or modification of docks less than $2,500 in value, irrigation systems, and pre-existing agricultural drainage and diking systems. The County issues a Letter of Exemption for projects exempted from the permit requirements. Usually, activities that are exempt from the SDP process are also exempt from environmental review under SEPA.

Non-exempt projects must complete the SEPA review process before the County can take action such as issuing a permit. A conditional use permit may be issued to allow greater flexibility in a manner consistent with the provisions of the SMP. In authorizing a conditional use, the County may attach special conditions to prevent undesirable effects of the proposed project. A variance may be granted for relief from specific bulk, dimensional, or performance standards set forth in the SMP where extraordinary or unique circumstances affect the property such that an unnecessary hardship is imposed on the applicant.

The SMP establishes four environmental designations for shorelines in the County: Urban, Rural, Conservancy, and Natural. The Skokomish River shoreline is designated as Rural from Hood Canal to the confluence of the North and South Forks, and Conservancy on both forks upstream from the confluence. A Rural designation is intended to protect agricultural land from urban expansion, restrict intensive development along undeveloped shorelines, serve as a buffer between urban areas, and maintain open spaces and opportunities for recreation compatible with agricultural activities (SMP, p. 10). The Rural designation also encourages farm management practices that prevent erosion and siltation of water bodies and minimize the flow of waste materials into watercourses.

For each environmental designation, non-exempt projects are permitted outright, require a conditional use, or are prohibited (SMP, p. 27-28). Permitted uses are preferred and meet the policies of the SMP, but are not exempt because of their dollar value or because they materially interfere with normal public use of the water or shoreline. A conditional use is not prohibited, but represents an exception to the general rules and requires a special review. The conditional use permit provides greater flexibility in the application of SMP regulations. Prohibited activities are those viewed as inconsistent with the shoreline environmental designation. A use or development not specifically identified under Project Classifications (SMP p. 27-28) is reviewed as a conditional use, employing performance standards relating to the most relevant category. The following activities specifically identified in the SMP relate to the Skokomish River basin.



SOURCES: Washington State Department of Ecology Wetlands Section, "Wetlands Regulations Guidebook." 1988.
WA 173-14

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Figure 5-3.
PERMIT PROCESS
SHORELINE MANAGEMENT ACT

- Agriculture (p. 28-30) — permitted
- Mining (p. 41-44) — conditional use
- Shoreline Defense Works (p. 66-67) (flood protection & stabilization) — permitted
- Diking (p. 66-67) — conditional use
- Dredging (p. 63-65)
  - — water dependent use — permitted
  - — non-water dependent use — conditional use
- Landfill (p. 61-62)
  - — water dependent use upland — permitted
  - — water dependent use between OHWM and upland area — conditional use
  - — non-water dependent use upland — conditional use
  - — non-water dependent use between OHWM and upland area — prohibited
- Piers and Docks (p. 71-75) — permitted

Update Project Classification List

The SMP supplies a list of activities and indicates whether they are permitted uses, conditional uses, or prohibited in the Rural shoreline designation (p. 27-28). Several of the categories do not make distinctions for the purpose of the activity (e.g., dredging, landfill). If an activity is not listed under Project Classification, it is considered a conditional use. A number of activities associated with land use and flood control measures in the basin are not on the project classification list. To ensure that all desired activities have a clear regulatory basis in the SMP, the project classification list should be updated to include and amend the following items and their classification (C indicates conditional uses; P indicates permitted uses):

~~Shore Defense Works~~	
~~Diking~~	~~C~~
Flood Control Measures	
Bank Stabilization	P
Bank Restoration	
under 200 cubic yardsP	P
over 200 cubic yards	C
Gravel Removal	P
Log and Debris Removal	P
Dikes, Levees and Berms	P
Drainage Channels	P
Drainage Improvements	P
Flood Corridor Maintenance	P
Tree Removal	P
Dredging	
Water Dependent	P
Flood Control	P
Non-Water Dependent	C

Mason County Flood Damage Prevention Ordinance—No. 59-91

The Flood Damage Prevention Ordinance of Mason County was enacted in May 1991 to provide regulations controlling development activities for areas of the county subject to periodic flooding from streams and rivers. The ordinance states in Finding of Facts (Section 1.2) that "current methods of flood control, particularly in the Skokomish Valley, have proven unsatisfactory to local residents and governmental agencies. Comprehensive flood control measures are necessary to satisfy governmental concerns but which will at the same time allow property owners to protect their property." Section 5.4 of the ordinance designates the Skokomish Valley as a Special Flood Risk Zone and provides a set of interim regulations. These interim regulations are to be replaced by amendments that will follow adoption of this CFHMP. The role of diking in comprehensive flood control efforts is recognized in development of this CFHMP.

The Flood Damage Prevention Ordinance specifies general and specific standards for construction in areas of special flood hazards as shown on the Federal Insurance Rate Maps. General standards include anchoring all new construction and substantial improvements, using construction methods and materials that are resistant to flood damage, designing new and replacement water and sewage systems to minimize or eliminate infiltration of flood waters, ensuring that new subdivision proposals are consistent with the need to minimize flood damage, and using historic flood data where current elevation data are not readily available. Specific standards for residential construction, non-residential construction, accessory structures, critical facilities, and manufactured homes include elevating the lowest floor above the base flood level, providing openings in enclosed spaces below the lowest floor above the base flood level, providing openings in enclosed spaces below the lowest floor to allow free flow of flood waters, and using structural components capable of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy.

The ordinance generally prohibits such encroachments into floodways as fills, new construction and other substantial improvements. These restrictions are relaxed for the Skokomish River Valley, which has its own set of regulations, including the following:

- New construction and substantial improvements are allowed, provided the lowest floor is elevated one foot or more above base flood elevation. The highest portion of any lot is to be used as the building site. Elevating structures through the use of posts, piles and stem walls is preferred over the use of fill. Where feasible, new structures should be placed in the hydraulic shadow of existing structures.
- Areas where flood waters overflow the main channel are not to be altered (e.g., diked or leveed) in a manner that would increase stream flow until these regulations are amended in accordance with this Plan. Maintenance of existing levees, dikes, and other water flow modifications is permitted as long as such maintenance does not increase stream flow. Emergency alterations to such structures is allowed for the protection of human life and property. Alterations to such structures to prevent legitimate potential emergency situations are also allowed.

- Any fill allowed is to be confined to the actual building site and, to the extent feasible, fills are to be compensated for by cuts or extraction of like amounts of material. Solid road fills perpendicular to the flow of water are prohibited.

Washington State Hydraulic Code—RCW 75.20.100-140

The Washington State Hydraulic Code regulates activities affecting the state's salt and fresh waters. The purpose of the Hydraulic Code is to preserve fish and wildlife habitat in and around waters of the state. The Hydraulic Code is administered by WDFW, which has jurisdiction over projects to be constructed in salt or fresh waters that have contained salmon. Any work that falls within the definition of a hydraulic project requires written approval, referred to as a Hydraulic Project Approval (HPA), from WDFW. Hydraulic projects are defined as any work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state. Most flood control projects in the Skokomish River basin will require an HPA permit.

Application consists of a form submitted to WDFW accompanied by plans and specifications of the proposed project. The HPA permit process is illustrated in Figure 5-4. Any one of the following may constitute an application for an HPA:

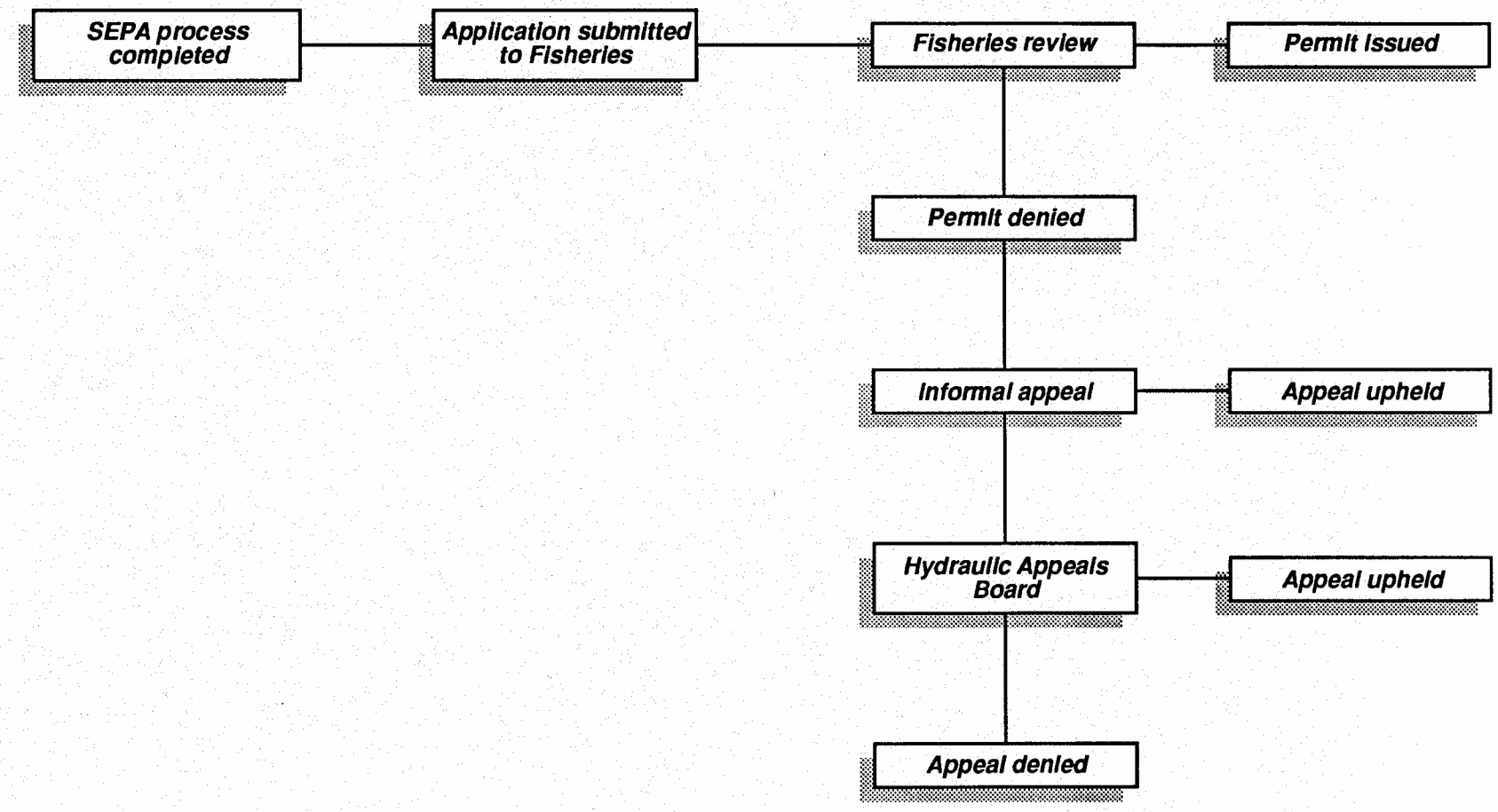
- A completed hydraulic approval application submitted to WDFW
- A completed forest practice application submitted to DNR
- A Section 10 or 401 public notice circulated by COE.

Verbal approval for emergency work may be granted immediately upon request to repair existing structures, remove stream obstructions, restore banks, or protect other property subject to immediate danger by weather, flood, or other natural causes. Verbal approval may also be granted immediately for driving across a stream during an emergency. Verbal approvals must be reduced to written approvals within 30 days. "Emergency" is defined as an immediate threat to life or public or private property, or an immediate threat of serious environmental degradation due to weather, stream flow conditions, or other natural conditions.

The Hydraulic Code specifies technical provisions for hydraulic projects. Fresh water technical provisions applicable to the Skokomish River basin are defined in code rules WAC 220-110-050 through 220-110-220. The technical provisions do not automatically apply to each HPA, as each application is reviewed individually. Restrictions to the project or the site may be imposed beyond those found in the technical provisions. A hydraulic project application may be denied if WDFW rules that it is directly or indirectly harmful to fish life and adequate mitigation cannot be assured by conditioning or altering the proposal. The code specifies that protection of fish life is the only grounds for denying or requiring conditions on an application.

Clean Water Act

The federal Clean Water Act of 1977 and the Water Quality Act of 1987 establish the framework for a national approach to water quality policy and protection. The goal of these federal laws is to eliminate pollutant discharges into the nation's navigable waters. The provisions of Sections 401 and 404 are applicable to the Skokomish River basin.



SOURCE: Washington State Department of Ecology Wetlands Section, "Wetlands Regulations Guidebook." 1988.

KCM 1917 First Avenue Seattle, Washington 98101	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 5-4. PERMIT PROCESS HYDRAULIC CODE

Section 401—Water Quality Certification

Section 401 ensures that activities requiring a federal permit comply with the Clean Water Act, state water quality laws, and other appropriate state regulations (e.g., the Hydraulic Code). Section 401 is implemented through a certification process. Ecology administers Section 401 requirements, tracks the responses of other state reviewing agencies, and is the final authority for approval, denial, or special conditions for certification.

A Water Quality Certification certifies that an activity requiring a federal permit will comply with water quality standards and discharge limitations for waters of the State. The Certification is similar to a permit and is required under Section 401 as a prerequisite to obtaining a COE permit (e.g., Section 404 and Section 10). Most instream construction activities, including flood hazard management projects such as bank stabilization and gravel bar scalping, will unavoidably violate state water quality standards on a short-term basis. Such projects will require a Temporary Modification of Water Quality Standards, which is an order issued by Ecology to control short-term activities that are in the public interest (e.g., flood control). The order may be required before Ecology issues a Water Quality Certification, and it must comply with SEPA requirements.

Section 404—Dredge and Fill Requirements

Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into waters of the US, including wetlands. The COE administers the provisions of Section 404 through a permit program. Discharges of dredged or fill material in wetlands may require either a nationwide permit or an individual permit. Nationwide permits are issued to authorize specific categories of work, including minor road crossing fills and replacement, repair, and rehabilitation of existing structures. The nationwide permit is required for smaller projects and the review process for obtaining this permit typically takes less than 20 days. The main nationwide permit dealing with wetland fills is Nationwide Permit 26.

Individual permits are required for wetland projects involving the following:

- Fill of less than 10 acres not authorized under Nationwide Permit 26
- Fill for more than 10 years
- Fill of any area in wetlands below the headwaters of and adjacent to a stream
- Fill of any area in tidal waters and their adjacent wetlands.

The review process for an individual permit includes an analysis by the COE of whether the project's benefits outweigh the potential environmental impact. In this case the benefits of flood control activities would be analyzed for their environmental consequences. Completion of an Environmental Impact Statement may be necessary for large-scale flood control projects. There is a 30-day review period to allow comment by federal, state, and local agencies, Tribal organizations, interest groups, and the general public.

Proposed wetlands projects may be subject to other laws in addition to or in association with a Section 404 permit. For example, Ecology has the right to place conditions on or request denial of a Section 404 permit if a proposal does not comply with state water quality laws. The COE cannot issue a Section 404 permit if the state has denied water quality certification. In addition, the COE will deny the 404 permit if a County permit associated with the project is denied.

Aquatic Land Lease or Authorization—RCW 79.90

An Aquatic Lands Lease or Authorization is required for any project undertaken within navigable waters of the state. Rules governing the lease or use of state aquatic lands are found in WAC 332-30 and RCW 79.90. "Navigable" is defined in RCW 88.40 as "waters of the state and their adjoining shorelines that are subject to the ebb and flow of the tide and/or are presently used, have been in the past, or may be susceptible for use to transport intrastate, interstate, or foreign commerce." The Skokomish River is considered navigable from Hood Canal to the confluence of the North and South Forks.

Aquatic land use authorization treats such lands as a limited natural resource, providing for their environmental protection and sound management. Application for use or lease of state aquatic lands is made to DNR. Aquatic land activities that interfere with the general public use of an area require agreement, lease or permit. All other applicable permits must be acquired for aquatic land projects, but if authorization from DNR is required in order to first receive another permit, it may be given conditioned upon receipt of that permit.

In the Skokomish River basin, Aquatic Lands Authorization is necessary for dredging, mining, and gravel removal in the main channel. If gravel is removed for the purpose of re-sale, DNR will charge a fee and a lease will be required. If gravel removal and dredging are part of a project in the public interest and undertaken by a public entity, then no fee will be charged. Presumably, this includes coordinated flood control projects. Dredging and gravel spoils may be used as fill or in the construction of public projects.

PERMIT PROCESS

No person shall be stopped from responding to any emergency per WAC 220.110.020(7) and RCW 75.20.103.

The previous section identified the general regulatory requirements and the organizations responsible for their implementation. Many development activities will require permission or permits from multiple levels of government. Activities identified as associated with existing land uses and flood control measures recommended in this CFHMP include the following:

- Bank stabilization for prevention of continued erosion
- Bank restoration in a pre-flood event location
- Dredging
- Gravel removal or bar scalping for purposes of flood control
- Log and debris removal from main channel, creeks, and drainage corridors
- Diking, including use of levees and berms
- Construction of residential structures
- Construction of accessory structures
- Construction of piers and pilings
- New construction and maintenance of drainage channels
- Drainage improvements, such as culverts and swales
- Preservation and enhancement of natural flood flow corridors
- Tree removal; stream or channel blockage prevention
- Mining, including gravel harvesting
- Landfill, including use of dredging spoils in flood control or repair.

The permits and authorizations required for these activities are shown in Table 5-1.

The permit process begins with application to the County for a permit to undertake one or more of the activities listed above. If the project occurs in a floodplain and is not an exempt activity, it requires a development permit under the Flood Damage Prevention Ordinance. If the project occurs within 200 feet of a shoreline as defined in the SMP, it must be declared Exempt or will require a Shoreline Substantial Development Permit (see Figure 5-3). Application for these permits may be made concurrently, but neither is issued until all other permits and authorizations have been acquired from state and federal agencies.

The project is then evaluated for SEPA compliance (see Figure 5-2). A determination is made as to whether the project meets exemption criteria. If it does not, an Environmental Checklist is prepared and a DNS, or a DNS with mitigation requirements, is issued if it is demonstrated that the project has no significant environmental impact. If it is determined that the project has significant impact, an EIS is required. SEPA compliance generally takes a minimum of two months and will be substantially longer if an EIS is required. SEPA compliance must be established before subsequent permits can be issued.

Upon completion of the SEPA process, if the project occurs in or near waters of the state and their associated wetlands, an HPA is required from WDFW. An HPA will be issued up to 30 days after SEPA compliance (see Figure 5-4). A Temporary Water Quality Modification and Water Quality Certificate is required from Ecology and is issued up to 30 days after receiving an HPA. Application for these approvals may be made concurrently, but HPA approval precedes Water Quality Certification/Modification approval.

If a project occurs in a wetland, a COE Section 404 permit is required. If the project falls under a National Wetlands Permit, approval can be obtained within 30 days. If not, COE approval can take as long as six months. The COE does not take action on an application until SEPA has been satisfied and a Water Quality Certificate issued.

If a project involves work in the main channel of the river, an Aquatic Lands Authorization is required from DNR. Application for use of aquatic lands may run concurrent with other permits after SEPA compliance has been established. Authorization is conditioned on receiving all other permits. The overall permit process is summarized in Figure 5-5.

FEDERAL AND STATE PROGRAMS: BUYOUT/RELOCATION/ FLOODPROOFING

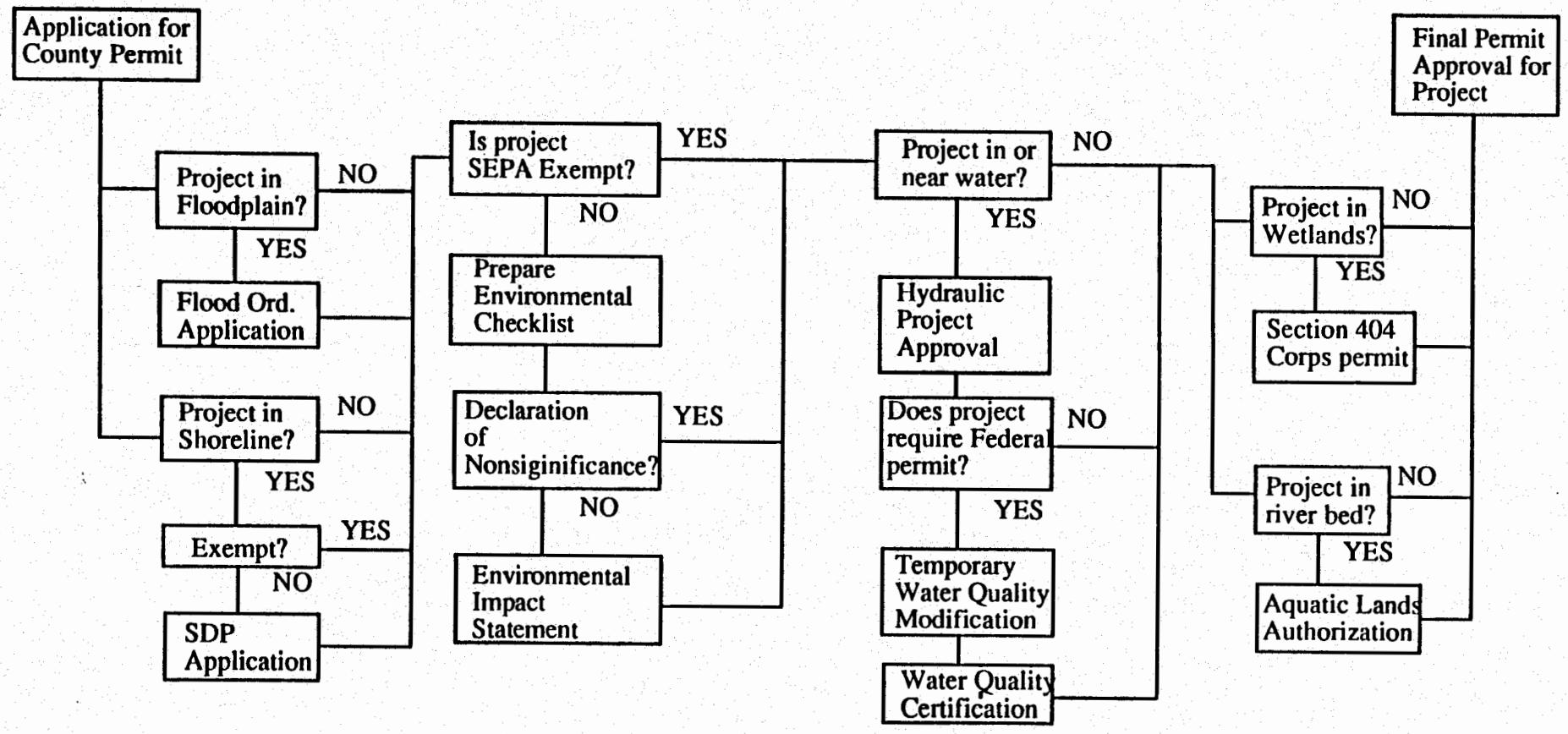
Recent catastrophic flooding in the Midwest has prompted a national review of flood hazard mitigation programs. This review has resulted in a shift away from the historic lack of support for buyout, relocation, and floodproofing programs. This changed approach is reflected in new federal and state programs that are targeted at mitigation and prevention of repetitive flood damage.

There are currently two federal programs and two state programs through which buyouts, relocation or floodproofing may occur. The two federal programs are implemented under the Reigle Community Development and Regulatory Improvement Act and the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The Reigle program takes the place of a similar program implemented under Section 1362 of the National Flood Insurance Act. The two federal programs differ in that the latter is designed for assistance during federally declared disasters, while activities under the former take place during non-emergency times.

TABLE 5-1.
PERMIT REQUIREMENTS FOR SELECTED ACTIVITIES IN THE SKOKOMISH RIVER BASIN

	Cons	Rural	SEPA Compliance	Flood Damage Prevention Ordinance	HPA Permit	Water Quality Certification	Temp. Water Quality Modification	Sec. 404 Permit	Aquatic Lands Approval
Bank Stabilizing	C√	P√	√		√	√	√	√	
Bank Restoration	C√	C√	√		√	√	√	√	
Piers & Pilings	C√	P√	√		√	√	√	√	
Residential									
Single Family	E	E		√					
MultiFamily	C√	P√	√	√					
Accessory Dwelling	P√	P√	√	√					
Dredging	C√	C√	√		√	√	√	√	√
Gravel Removal	C√	C√	√		√	√	√	√	√
Diking, Levees, Berms	C√	C√	√	√		√	√	√	
Drainage Channels	C√	C√	√	√	√	√	√	√	
Drainage Improvement	C√	C√	√	√		√	√	√	
Flood Flow Enhancement	C√	C√	√	√		√	√	√	
Tree Removal	C√	C√			√				
Log/Debris Removal	C√	C√	√		√			√	
Mining	C√	C√	√		√	√	√	√	√
Landfills	C√	C√	√	√	√	√	√	√	

SMP Designations:
E - exempt
√ - permit, approval or compliance required
P - permitted use



KCM
1917 First Avenue
Seattle, Washington 98101

Mason County
SKOKOMISH RIVER COMPREHENSIVE
FLOOD HAZARD MANAGEMENT PLAN

Figure 5-5.
OVERALL PERMIT PROCESS

The Washington State Hazard Mitigation Grant Program is the mechanism through which the various program elements of the Stafford Act are implemented. The other state program under which buyouts, relocation, or floodproofing may occur is the Flood Control Assistance Account Program (FCAAP).

Reigle Community Development and Regulatory Improvement Act

Title V of the Reigle Community Development and Regulatory Improvement Act of 1994 (Public Law 103-325) is referred to as the National Flood Insurance Reform Act of 1994. One of the major provisions of the act is the establishment of a program to provide financial assistance to states and communities for planning and implementing flood mitigation activities. Details on the program are contained under Subtitle D—Mitigation of Flood Risks.

A National Flood Mitigation Fund is set up through the act to fund flood mitigation planning and implementation activities. Money for this fund comes from the National Flood Insurance Fund. The total amounts to be credited to the new mitigation fund are as follows:

- $10,000,000 in the fiscal year ending September 30, 1994
- $15,000,000 in the fiscal year ending September 30, 1995
- $20,000,000 in the fiscal year ending September 30, 1996
- $20,000,000 in each fiscal year thereafter.

Repeal of Previous Programs

The first two sections of Subtitle D repeal Sections 1362 and 1306c of the National Flood Insurance Act of 1968, containing provisions for acquisition of property located in flood-risk areas. A one-year transition period from the enactment of the Reigle Act, on September 23, 1994, is provided for final implementation of activities under Sections 1362 and 1306c.

Conditions

The following conditions for participation in the program are described in the Act:

- A "community" is defined as a political subdivision that has building code and zoning code jurisdiction over the flood hazard area, and is participating in the flood insurance program.
- To be eligible for funding for activities, the state or community must have a flood risk mitigation plan that:
  - — Describes the activities to be funded
  - — Is consistent with specific criteria contained in section 1361 of the National Flood Insurance Act of 1968 (*Criteria for Land Management and Use*)
  - — Provides protection to structures which are covered by an existing flood insurance policy
  - — Is approved by the Director

  - Includes a comprehensive strategy for mitigation activities for areas affected by the plan
  - Has been adopted by the State or the community following a public hearing.

- The Director (FEMA) has 120 days in which to review submitted mitigation plans and notify the State or community that the plan has been approved or disapproved.
- Funding can be used only for activities included in the approved plan. Activities must be technically feasible, cost effective, and cost-beneficial to the National Mitigation Fund. Mitigation activities for repetitive loss structures and structures that have incurred substantial damage will receive higher priority.

Funding

The different funding limits for planning and implementation activities under the act are described below. Both categories of grants are provided on a 75 to 25 percent federal to local cost-share basis.

Planning

- The total amount available for mitigation planning will be $1,500,000 per year. Single grants to states and communities cannot exceed $150,000 and $50,000, respectively. The total amount of grants to any one state and all communities in that state in a fiscal year may not exceed $300,000.
- Grants for mitigation planning to states or communities cannot be awarded more than once every 5 years and each grant may cover a period of 1 to 3 years.

Implementation

- Limits on grants for mitigation activities during any 5-year period may not exceed $10,000,000 to any state or $3,300,000 to any community. The sum of the amounts of mitigation grants made during any 5-year period to any one state and all communities in that state is limited to $20,000,000.
- The limits on grants for mitigation activities described above can be waived for any 5-year period during which a major disaster or emergency is declared by the President as a result of flood conditions in the state or community.

Eligible Activities

The act lists specific activities that are eligible for funding as follows:

- Demolition or relocation of any structure located on land along the shore of a lake or other body of water that is certified by an appropriate state or local land use authority to be subject to imminent collapse or subsidence as a result of erosion or flooding

- Elevation, relocation, demolition, or floodproofing of structures (including public structures) located in areas having special flood hazards or other areas of flood risk
- Acquisition for public use by states and communities of such properties (including public properties) located in areas having special flood hazards or other areas of flood risk, and properties substantially damaged by flood, as the Director determines is consistent with sound land management and use in such an area
- Minor physical mitigation efforts that do not duplicate the flood prevention activities of other federal agencies and that lessen the frequency and severity of flooding and decrease predicted flood damages, which shall not include major flood control project such as dikes, levees, seawalls, groins, and jetties unless the Director specifically determines in approving a mitigation plan that such activities are the most cost-effective mitigation activities for the National Flood Mitigation Fund
- Beach nourishment activities
- The provision of technical assistance by states to communities and individuals to conduct eligible mitigation activities
- Other activities that the Director considers appropriate and specifies in regulation
- Other mitigation activities not described above that are described in the mitigation plan of a state or community.

Section 1362 of the National Flood Insurance Act of 1968

As described above, the Reigle Community Development and Regulatory Improvement Act rescinded Section 1362 of the National Flood Insurance Act. The following discussion is presented for informational purposes.

Section 1362 of the National Flood Insurance Act of 1968 authorized the Secretary of Housing and Urban Development to purchase properties located in flood risk areas from willing sellers. The purchased property was then transferred to state or local governments. To qualify for purchase, properties must have met the following three criteria:

- Been damaged substantially beyond repair by a flood, or damaged by floods on not less than three previous occasions in 5 years with the cost of repair averaging at least 25 percent of the value of the structure
- Been covered by flood insurance
- Been located in any flood-risk area, as determined by the Secretary.

Section 1362 provided an opportunity for a federal agency to establish a continuing program to purchase properties for the specific purpose of reducing future flood losses, as opposed to purchasing properties as part of an individual project.

Section 1362 also contained provisions for granting low interest loans (2 percent rate for 10-year term) for the purpose of elevation of structures. Structures must have been located in a regulatory floodway and insured under the flood insurance program. Structures were to be elevated so they would not interfere with the flow of water from the base flood within the regulatory floodway. A total of $4,500,000 was set aside for these activities.

National Flood Insurance Program—Regulations for Floodplain Management and Flood Hazard Identification: 44 CFR, Part 77—Acquisition of Flood Damaged Structures

Part 77 contains procedural details relating to the broad policy established under Section 1362. While these provisions may be revised following completion of guidelines for planning and implementation activities funded under the new National Flood Mitigation Fund, they are presented here for informational purposes. Part 77 modifies the criteria for purchase of real property under Section 1362 by adding two criteria as follows:

- A state or community must enter into an agreement authorized by ordinance or legally binding resolution to take title to and manage the property in a manner consistent with sound land management use as determined by the Federal Insurance administrator.
- The community must agree to remove without cost to FEMA, by demolition, relocation, donation, or sale, any damaged structures to which the community accepts title from FEMA. This criterion includes the possibility that FEMA may assume part or all of the cost of the removal.

The following series of steps for acquisition and disposition of property are presented within the regulations:

- The property owner voluntarily agrees to sell the property
- Relocation assistance is not available to property owners who sell their property under Section 1362
- The property is appraised based on the *Uniform Appraisal Standards for Federal Land Acquisitions* published by the Interagency Land Acquisition Conference, GPO (1973). Appraisals are made based on the adjusted (for time), pre-damage fair market value of the structure and land. Compensation also includes flood insurance claim payments resulting from the most recent flood if the repairs have not yet been made
- FEMA purchases property that meets the criteria described above
- The title is subject to specific restrictive covenants, conditions, and agreements, which will run with the land and be binding on subsequent successors, grantees, or assigns. Specific criteria from which deed restrictions will be developed may include:
  - The land must be dedicated in perpetuity for open space purposes
  - The community will manage the land for its dedicated purposes

  - The community will not, without the prior approval of the Administrator, erect or permit to be erected any structures or other improvements on the land unless the structures are, except for restrooms, open on all sides and functionally related to a designated open space use
  - The community will permit no use that will create a threat to human life from flooding
- The State or community joins in execution of and takes title to and manages the property as described above
- The property is transferred subject to all relevant and applicable local laws and regulations
- The community agrees to remove damaged structures as described above
- The rights to enforce the restrictive covenants are assigned to the Administrator, with a declaration that any future violations may result in the reversion of title to FEMA.

Allowable open space uses of the property, listed in the regulation, include the following:

- Parks for outdoor recreational activities
- Nature reserves
- Cultivation
- Grazing
- Camping (except where adequate warning time is not available to allow evacuation)
- Temporary storage in the open of wheeled vehicles that are easily movable (except mobile homes)
- Unimproved parking lots
- Buffer zones
- Open space areas that are part of Planned Unit Developments (PUDs).

Structures functionally related to these uses and also listed are as follows:

- Open-sided picnic and camping facilities
- Kiosks and refreshment stands
- Non-habitable, elevated, or floodproofed service structures associated with a marina.

Any such structures are required to be built in accordance with the deed restrictions and floodproofed or elevated to withstand the effects of the 500-year flood.

Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288)

The Robert T. Stafford Disaster Relief and Emergency Assistance Act (The Stafford Act) provides assistance following Presidential declarations of major disasters. Title IV presents details on major disaster assistance programs, including provisions for property acquisition and relocation assistance. Cost-sharing is available for up to 75 percent of the cost of any hazard

mitigation measures that "the President has determined are cost-effective and which substantially reduce the risk of future damage, hardship, loss, or suffering in any area affected by a major disaster." However, the total amount of mitigation funding under any disaster declaration cannot exceed 15 percent of the total grant funds provided for that disaster.

The specific terms and conditions used to determine if an acquisition or relocation project is eligible to receive federal funding under the Stafford Act are as follows:

- Acquisition and relocation projects funded under this act must be cost-effective and must substantially reduce the risk of future damage, hardship, loss or suffering in any area affected by a major disaster
- Acquisition and relocation projects and all other mitigation measures must be identified based on an evaluation of natural hazards
- The applicant (the county or the state) must complete an agreement stating that:
  - The property will be dedicated and maintained in perpetuity for a use compatible with open space, recreational, or wetlands .management practices
  - The only new structures to be erected on the property are public facilities that are open on all sides and functionally related to a designated open space, rest rooms, or structures approved by the Director in writing before the start of construction
  - No application will be made for additional disaster assistance for projects relating to the property and no federal funding will be granted for such projects.

State Hazard Mitigation Grant Program

The Washington State Department of Community, Trade, and Economic Development (CTED) coordinates state disaster mitigation, preparedness, response and recovery activities. Under this mandate, the agency administers the State Hazard Mitigation Grant Program (also called the 404 Program after the section of the Stafford Act dealing with Hazard Mitigation), which is authorized and partially funded under the Stafford Act. State Hazard Mitigation Grants are made to local governments on a cost-share basis, with the federal, state, and local percentage matches set at 75, 12.5, and 12.5 percent, respectively. Federal funding for this program is contingent on a Presidential disaster declaration. The nonfederal share may vary by disaster. State and federal money distributed under this program can be used only for acquisition of property and demolition of structures. Funding cannot be used for elevation of structures or relocation of residents.

Funding for the program since 1989 has totaled approximately $9 million, with approximately $6 million coming from the federal government and $3 million from state sources. Even with this apparently high level of mitigation funding, total requests by applicants for State Hazard Mitigation Grants have consistently exceeded available funds. Therefore, the state has established a competitive procedure for funding. Applications are reviewed by a panel of state and local officials and scored based on how well they meet the specific terms and conditions

required by the Stafford Act (see discussion of Stafford Act above). This process is administered by CTED. Selected applications are then sent to FEMA for approval.

Flood Control Assistance Account Program

Funding for flood control maintenance projects and preparation of CFHMPs are available through FCAAP. It may be possible to receive funding for acquisition, relocation, or floodproofing activities as a type of maintenance project. Distribution of FCAAP grant money depends on the amount appropriated by the state legislature each biennium and is based on the eligibility of the applicant and the proposed project. Conditions for funding include the following:

- Grants are limited to 50 percent of the total cost for non-emergency projects
- The non-emergency FCAAP contribution is limited to $500,000 per county
- Emergency funds of up to $150,000 per county per biennium are available on a first come/first served basis; the State will fund up to 80 percent of the cost of emergency projects
- Unused emergency funds ($500,000 total emergency fund) can be disbursed on a discretionary basis by Ecology
- The state can fund 75 percent of the cost of comprehensive flood hazard management plans.

LOCAL FUNDING OPTIONS

A brief listing of local approaches for partial or complete funding of buyout, relocation, or floodproofing projects is as follows:

- Flood Control Zone Districts (FCZDs), such as the one for the Skokomish River, have the authority to use several different funding mechanisms to achieve locally identified goals. It is conceivable that funds from the FCZD can be used to meet part or all of the costs of buyout, relocation, or floodproofing programs.
- Provisions for River Improvement Funds are included in RCW 86.12. Originally, the purpose of the fund was to finance drainage activities related to flood control, but it can be and is being used in some counties to fund activities related to flood or stormwater control as specified in RCW 86.12.020.
- Local Improvement Districts (LIDs) allow the county to issue bonds for the cost of improvements and to recover the cost through assessments made on "specially benefiting" property. Special benefit is determined by the increased property value resulting from the improvements. This approach is typically used to fund development of local infrastructure.
- It may be possible to use a number of County funding sources, including county general funds, to finance all or part of a buyout, relocation, or floodproofing program.

LAND SWAPS

The land swap approach involves a transfer of government-held land to private property owners willing to relocate from their flood-prone property. Once acquired by the government, any structures on the property are demolished and the property is used for open space purposes, thereby eliminating the flood hazard. The land swap approach is being considered for acquisition of flood-prone properties in the town of Hamilton in Skagit County.

Hamilton is located just north of the Skagit River, approximately 10 miles east of the town of Sedro-Woolley. The CTED and FEMA have been working with citizens of the town to complete a program of acquisition and relocation, possibly involving a land swap. The government agencies involved made several attempts to identify and purchase properties to which residents could be relocated; however, prices for these properties increased beyond the available funding after they were identified. The current focus for the town is to relocate the fire hall and a pump station to a new town center, outside the flood-prone area.

LOCAL EXPERIENCES

Three previously completed Flood Hazard/Floodplain Management Plans containing provisions for buyout, relocation, or floodproofing, and descriptions of historical experiences in these areas were reviewed in order to gain an understanding of how other communities have planned for and implemented these activities. Summaries of relevant sections of the following three plans are presented below:

- King County Flood Hazard Reduction Plan
- City of Snoqualmie Floodplain Management Plan and Repetitive Loss Plan
- Lewis County Comprehensive Flood Hazard Management Plan.

King County Flood Hazard Reduction Plan

Background

The King County Flood Hazard Reduction Plan was completed in January 1993 and presents a program of flood hazard management actions for the following six river basins within the county:

- Skykomish River Basin
- Snoqualmie River Basin
- Sammamish River Basin
- Cedar River Basin
- Green River Basin
- White River Basin.

The plan was developed to prevent or mitigate damages from future floods that may be similar to or more extreme than previous floods. The Thanksgiving 1990 flood alone caused more than $15 million in damage in King County. The plan addresses the following topics:

- Policies to guide floodplain land use and flood control activities in King County

- Program and project recommendations, including capital improvement projects, maintenance, relocation, and elevation of homes, and flood warning improvements and river planning activities
- Implementation priorities for program and project recommendations
- An analysis of major financing alternatives and issues.

Relocation and elevation have never before been funded in King County. The following positive characteristics of these approaches are described in the plan:

- Cost-effective and permanent solution to flooding, particularly in low-density areas
- None of the ongoing repair costs associated with structural CIPs
- Reduces public expenditures for flood insurance claim payments
- Can increase flood storage and conveyance capacity (relocation)
- Creates open space areas along the major rivers (relocation)
- Provides added benefits of public river access and preservation of wildlife habitat (relocation)
- Reduces public expenditures for repair of existing flood- and erosion-control facilities (relocation)
- Costs less than a new levee or levee improvement (elevation)
- Does not create a new maintenance commitment (elevation)
- Makes citizens eligible for lower flood insurance rates (elevation).

Relocation can involve either demolition of a structure and relocation of its residents, or the relocation of the structure itself. King County would acquire the land previously occupied by the structure in both cases. The plan cites the high costs of relocating a home and its residents as the reason relocation should be recommended only in very high hazard areas subject to deep, high velocity flows or undercutting due to channel migration.

Elevation involves raising the finished floor of a structure above the predicted level of the 100-year flood, thus reducing the potential for flood damages. Elevation is considered appropriate in areas where homes are subjected to low velocity floodwaters. Elevation is inappropriate in areas subject to high velocity flows (e.g., the FEMA floodway) because the home would still be at risk of serious damage or collapse. Elevation is also inappropriate in areas where a home is threatened by bank erosion.

Policies

The following policies relating to relocation and acquisition are presented in the plan:

Voluntary Acquisition Versus Condemnation

County acquisition of threatened buildings should be voluntary on the part of the property owner except under the following limited circumstances:

- Federal, state, or local regulations prohibit reconstruction of the building
- The property in question is causing significant flood damage to other properties
- A property owner refuses to sell a portion of an area in which the majority of property owners have agreed to sell to the county
- A property owner refuses to sell an area needed to complete an approved capital improvement project.

Strong points are made in the plan regarding property owners rights. The plan indicates that no projects will be implemented without extensive discussion between the County and the affected homeowners. Site-specific recommendations presented in the plan are described as preliminary, contingent on the response of affected property owners. Homeowners are given the final say whether their home is relocated or purchased by the County in nearly all cases.

Using Land Created by Relocation or Acquisition

Vacant land is created when structures are relocated, or acquired and demolished by the County. This land will have value as open space, habitat, parks, or agricultural land. Open land created by the relocation or acquisition of structures should either become a County easement (if the structure is relocated to another site on the same lot) or be owned and managed by King County as open space, riparian corridor, agriculture, or a recreation area.

Recommendations

A total of 44 potential relocation projects are identified in the plan, involving relocation of 347 structures at an estimated cost of $49.4 million. A total of 18 potential elevation projects are identified in the project at an estimated cost of $4 million. The total cost of relocation and elevation is $53.5 million, approximately 17 percent of the total cost of all recommended capital projects.

Costs for relocation projects include the following:

- Fair market value of the structures and properties (Unit costs of $180,000 were assumed for house relocation and $24,000 for mobile home relocation)
- Appraisals and title searches
- Developing and managing contracts for demolition or relocation of structures
- Preparation and tracking of permits
- Working with residents to clarify the project proposal
- Coordinating with other affected agencies.

For the purposes of estimating relocation costs, it was assumed that the structure would be acquired and demolished, rather than moved.

Costs for elevation projects include the following:

- Average of $24,000 for elevation of a fixed structure (actual costs will vary depending on the size and design of each structure)

- Managing construction contracts
- Obtaining necessary permits
- Working with property owners.

City of Snoqualmie Floodplain Management Plan and Repetitive Loss Plan

The City of Snoqualmie faces flood hazards from the Snoqualmie River. The river is constricted as it flows over Snoqualmie Falls. During flood events, backwater from the falls spreads over the floodplain upstream of the falls, inundating most of the developed portion of the City. Damages to property during the 1990 flood were estimated at $15 million.

The City developed a Floodplain Management Plan and Repetitive Loss Plan in order to minimize future damages in the floodplain. The Plan was adopted in September 1993. Properties that have repetitive losses are defined as those having two or more claims of at least $1,000 that have been paid by the National Flood Insurance Program since 1978. Twenty-one properties were identified by the City as repetitive losses in 1993.

The City has participated in the Community Rating System (CRS) since 1992. The CRS, developed by FEMA, provides reductions in flood insurance premiums when communities complete activities to decrease flood hazards. Several activities completed by the City are documented in the Floodplain Management Plan and Repetitive Loss Plan and annual progress reports submitted under the program. Activities related to buyout, relocation, and floodproofing that have been completed include the following:

- Five properties were purchased and residences on them removed under the (since discontinued) FEMA 1362 program
- At least 28 residences have been elevated above the 100-year flood elevation
- The high school has been floodproofed
- The City maintains certificates of elevation for all post-FIRM structures and maintains files of COE surveys of building elevations originally prepared in 1981
- Twice a year the City mails to residents educational material describing flood protection measures that residents can complete
- The City requires that structures be built on engineered fill or pile foundations with flow-through features. The City also implements floodplain regulations that do not allow a net import of fill. Any import of needed structural fill must be compensated for by an equal amount brought out of the floodplain. The City maintains a log of fill activity in the floodplain.
- The City assists property owners who wish to elevate or floodproof their homes or businesses
- The City plans to require houses being substantially improved to be elevated at the same time
- The City plans to revise local regulations to require new structures to be built at least one foot above the base flood elevation.

Lewis County CFHMP

The Lewis County CFHMP, completed in 1994, addresses flood issues on the Chehalis, Nisqually, and Cowlitz Rivers. The major focus of the plan is on the Chehalis/Centralia region, where flooding has historically caused millions of dollars in damage. During the 1990 flood, residential damages in Centralia and Chehalis totaled $4.3 million. Approximately 905 residential dwellings were damaged during the flood.

COE Activities

The Lewis County CFHMP includes a summary of current and historical flood hazard reduction efforts. Since 1935, the COE and other agencies have proposed numerous structural flood control measures to prevent flooding in the Chehalis River valley, including dam construction and modification, channel alterations, levees, and pump stations. None of the major structural flood control measures have been approved or constructed due to environmental considerations, regulatory requirements, and a lack of funding.

The COE completed a Flood Damage Reduction Interim Feasibility Report and Environmental Impact Statement for the Centralia/Chehalis area in 1982. Evacuation and relocation of residential and commercial structures was determined not to be a viable alternative. Approximately 2,390 residences and 315 commercial, industrial, or public structures are located in the 100-year floodplain in Centralia. The plan indicates that economic and political considerations arising from this large investment in the floodplain area prohibit consideration of evacuation and relocation for the entire floodplain. The relocation of smaller areas was also determined to be unacceptable.

The COE also evaluated floodproofing as an alternative in their 1982 report. The cost of floodproofing all 1,300 residential and 130 commercial or industrial structures in Centralia was estimated to be $22,600,000 (1976 dollars). This cost included raising residential buildings so that all first-floor levels are above the 100-year flood, and modification of commercial and industrial buildings so that openings below the floodwater surface are watertight. While flood damage to residential and commercial structures would be largely eliminated, other adverse effects of flooding would continue, including damage to public streets and utilities, cutoff of roads and road access, disruption of police, fire, and ambulance service, and deposition of silt and debris. The COE determined that this alternative was not economically justified.

CFHMP Recommendations

Due to the history of inaction in implementing structural flood hazard management measures and based on input from the community, the CFHMP was developed to focus on nonstructural flood hazard management measures. Nonstructural measures recommended in the plan include the following:

- Improvement of flood warning and emergency response procedures
- Floodproofing of individual structures
- Completion of flood audits for residential and commercial buildings in the floodplain

- Modification of the flood damage prevention ordinances of Centralia, Chehalis, and Lewis County to achieve consistency in the valley
- Assessment of flood hazards using the best available historical flood records
- Modification of the Flood Insurance Rate Maps to represent flood hazard areas based on the actual flood inundation history.

The plan categorizes floodproofing approaches as permanent, contingent, and emergency. Permanent floodproofing is always in place and requires no action if flooding occurs. Floodwalls, levees, closures and sealants, elevation, and relocation are included in this category. Contingent floodproofing requires installation prior to the flood, and includes flood shields, watertight doors, and movable floodwalls. Emergency floodproofing techniques are improvised during flooding, and include sandbag dikes and earth-filled retaining walls.

The plan recommends establishing elevation and relocation as the preferred floodproofing method for the Centralia/Chehalis area. Relocation and elevation projects are recognized as having high short-term costs; however, they are the lowest-cost alternative in the very high hazard areas.

While the CFHMP was being prepared, the COE identified 15 flood-prone areas within the cities of Centralia and Chehalis based on historical FEMA flood damage reports. Residents in these areas were asked to participate in a flood audit program, and approximately 200 property owners did so, representing a 10 percent participation rate in the program.

The flood audit planned for the Skokomish Valley is similar to the Flood Audit completed for Lewis County. Additional details are provided under Issue 10 in chapter 6.

CHAPTER 6.
FLOOD HAZARD MANAGEMENT ISSUES, ALTERNATIVES, ANALYSIS, AND RECOMMENDED ACTIONS

INTRODUCTION

Flood hazard management issues for the Skokomish River are broad-ranging and complex. During the preparation of this CFHMP, a list of specific issues to be addressed was developed through a review of relevant materials, including minutes of PAC meetings, previous reports, and written correspondence. These issues were then discussed in more detail as members of the PAC and the public provided input during PAC meetings. Interim technical memoranda and reports were also prepared since completion of the 1993 draft. The following ten issues were identified:

- **Issue 1:** Forest practices in the South Fork Watershed have contributed to sedimentation in the lower mainstem, causing increased flooding.
- **Issue 2:** Diversion of flow from the Cushman Hydroelectric Project has changed the hydrologic regime of the river, reducing its sediment-carrying capacity and causing increased flooding.
- **Issue 3:** US 101 causes localized increases in flood levels.
- **Issue 4:** SR 106 causes localized increases in flood levels during extreme events.
- **Issue 5:** Overbank flow on the floodplain is not adequately conveyed back into the river following flood events.
- **Issue 6:** Structures located in the highest hazard areas receive repetitive damages, resulting in a cycle of damages, disbursement of state and federal funds for repairs, and later flooding and damages. This cycle is costly to both the property owner and the public.
- **Issue 7:** Future construction of homes and businesses in the Skokomish Valley will result in additional hazards to people and property. Floodplain development regulations are needed to both limit development so that current flooding problems are not exacerbated and provide guidance for development so that individuals can minimize flood hazards at specific locations.
- **Issue 8:** The current system of riverbank levees is discontinuous, the construction methods used to build them meet neither current engineering standards nor FEMA regulations. Any dikes constructed should meet basic structural standards and FEMA regulations, not cause increased flood hazards, and be set back from the natural stream channel and stream bank.
- **Issue 9:** Individual property owners should have flood protection through floodproofing.
- **Issue 10:** The current flood warning and emergency response program needs enhancement. Residents need to know when a flood is occurring or is likely to

occur and what its magnitude and duration might be in order to take appropriate measures to protect their property and evacuate to safe locations.

This chapter addresses each of the flood hazard issues in detail and recommends solutions for them. The following topics are presented for each issue:

- A description of the issue
- Alternatives that can be implemented to mitigate or prevent flood hazards associated with the issue
- A description of the analytical procedures used to select a preferred alternative
- A description of the recommended action(s)
- A list of key elements achieved through either completion of the section of the CFHMP or implementation of the preferred alternative.

No formal ranking was completed for the alternatives. The results of the analytical work were generally used to select the preferred alternative. Public and advisory committee input were also used to select the preferred alternative.

Many of the issues discussed in this chapter are inter-related. For example, Issue 1 focuses on the effect of forest practices on sedimentation in the lower mainstem, while Issue 2 focuses on the role of Lake Cushman Hydroelectric Project on sedimentation in the lower mainstem. Effects of both forest practices and the Cushman project influence the distribution of flood hazards in the lower valley, discussed in Issue 6. Since many of the issues are related, many of the alternatives address several problems.

STRUCTURAL ALTERNATIVE SUMMARY SHEETS

Structural and non-structural alternatives have been developed to address the issues presented in this chapter. In general, structural alternatives address the following objectives:

- Control of river alignment
- Protection of banks and in-stream structures
- Development and preservation of adequate conveyance capacity
- Floodplain protection
- Streambed control.

Summary sheets describing many of the structural approaches included in these categories is included with this report as Appendix S. The summaries describe each alternative's purpose, construction, and operation. Sketches are included to illustrate the alternative description, and the potential environmental impact is noted. Considerations for implementation are outlined, including design requirements, materials, equipment needs, and typical permits that may be required. Monitoring and maintenance activities to ensure that the project continues to meet its objective are also outlined. Valley residents and County officials can use these summary sheets in the future to compare alternative solutions to the problems identified in this CFHMP. These sheets can also serve as educational material in addressing flood hazard issues.

HYDRAULIC MODELING

Flood events on the Skokomish River can be simulated using a hydraulic model, allowing an assessment of the benefits of various structural measures on flood levels. The COE HEC-2 computer model "Water Surface Profiles" was used in this CFHMP to establish flood levels for existing conditions, as well as to assess the impact of measures such as gravel bar scalping, river channel widening, and highway bridge modifications.

The HEC-2 Model was applied to the Skokomish River from Annas Bay to a point on the South Fork approximately 2.5 miles upstream of its confluence with the North Fork. The reach selected for modeling included nearly 9 river miles of the mainstem of the Skokomish River and nearly 2.5 river miles of the South Fork.

Model Calibration

Hydraulic models are calibrated to ensure that they accurately represent observed conditions. The model uses known flow rates and topographic data to determine flood depths at specified cross-sections. Input parameters within the model are adjusted until the model results match those of a known event, at which point the model is said to be calibrated.

A flood event on the Skokomish River on December 20, 1994, has been characterized by many residents of the Skokomish River Valley, as well as the USGS, as the flood of record. According to the residents of the valley, the flood levels on December 20 surpassed those observed during the previous flood of record, on November 23, 1990. With the availability of observations made by the residents and gauge data from the USGS, the December 20, 1994, flood event was selected to calibrate the hydraulic model.

Discharge Data

Two pieces of information concerning the 1994 flood were needed to calibrate the computer model. The first was surveyed high water marks throughout the river valley. Valley residents provided this information by marking a location on a building, tree, or wall where they observed the highest water surface elevation during the flood event. A survey crew from the County then surveyed the exact elevation of the marks. The second was the peak flow rate in the river during the flood event. There are two sources for flow data, the USGS and measurements made for TPU.

USGS Flow Estimates for December 1994 Event

Since July 1943, USGS has maintained a gauging station on the upstream side of the US 101 bridge opening (Gauge 12061500). In March 1995, the USGS indicated that the gauge is not accurate during extreme floods (Wiggins, B., 7 February 1995, personal communication). The USGS maintains that the stage-discharge relationship for the gauge is unreliable and produces errors of up to 30 percent for stages greater than 15.5 feet (representing a flow of approximately 6,000 cfs). In addition, a substantial amount of the flow in the Skokomish River leaves the banks of the mainstem during extreme flood events, flows overbank through the Weaver Creek Bridge, and overtops US 101 near Purdy Creek. This flow pattern, which occurs during even moderate flood events, prevents the existing gauge from measuring the entire flow rate upstream of US 101.

During the December 20 flood event, the US 101 gauge recorded stage readings at 15-minute time intervals. The peak stage reading, at 4:15 AM on December 20, was 17.50 feet. According to the USGS, if the existing rating curve was extrapolated to estimate the flow in the mainstem, a peak flow between 60,000 and 70,000 cfs would result. The USGS does not feel that this flow estimate is correct (Wiggins, B., 7 February 1995, personal communication). The previous flood of record, November 23, 1990, resulted in a peak gauge reading of 16.80 feet. The 1990 flow estimate was computed by extrapolating on the stage-discharge relationship. It should be noted that the USGS maintains that the data used to transform the gauge readings to flow estimates, and not the gauge readings themselves, are in question.

The USGS is publishing a provisional peak flow value for the 1994 flood of 4,500 cfs in the North Fork (Wiggins, B., 7 February 1995, personal communication). Although only 87 cfs was released from Lake Cushman at the time of the peak, nearly 4,400 cfs of unregulated surface runoff was conveyed down the North Fork. This large runoff came from a 15.5-square-mile watershed downstream of the dam, where a moderate snow pack was melting rapidly prior to and during the peak of the flood event. The 4,500 cfs estimate is provisional, but the USGS considers it valid.

Between August 1931 and September 1984, the USGS maintained a water stage recorder (Gauge 12060500) on the South Fork, 3.2 miles upstream of the confluence with the North Fork, and 0.2 miles upstream of the confluence with Vance Creek. Based on high water marks in the vicinity of this gauge and historic stage-discharge information at this gauge, the USGS was able to estimate a peak flow in the South Fork, excluding Vance Creek flows, of approximately 20,000 cfs for the December 20 flood event.

Based on the North and South Fork flow estimates and a hydrologic analysis to account for the remainder of the watershed, the USGS estimated a peak flow rate of 30,000 to 32,000 cfs in the mainstem immediately upstream of US 101. Table 6-1 presents the flow estimates provided by USGS.

TABLE 6-1.
FLOW ESTIMATES PROVIDED BY THE USGS FOR THE DECEMBER 1994 FLOOD

Total Flow in Mainstem at US 101 (cfs)	South Fork (cfs)	North Fork (cfs)	Vance Creek (cfs)
30,000 to 32,000	20,000	4,500	Not estimated by USGS

Initial CFHMP Flow Estimates for December 1994 Event

In order to calibrate the hydraulic model, it was necessary to further refine the peak flow estimates for the December 20 flood event. This was accomplished using the USGS data, independent flow measurements conducted for TPU, and additional calculations to account for other flows.

The flow rates provided by USGS were for sub-watersheds within the entire Skokomish River watershed. The Skokomish River watershed upstream of US 101 covers 227 square miles. The drainage areas corresponding to the flow rates provided by USGS are 76 and 114.5 square miles for the South Fork and North Fork, respectively. The 114.5-square-mile North Fork drainage

area includes 99 square miles upstream of Lower Cushman Reservoir, which is non-contributing except during spillage, and 15.5 square miles downstream of the reservoir, which contributes runoff to the North Fork primarily through McTaggert Creek.

The first step was to estimate the flow rate in Vance Creek at the peak of the flood event. It was assumed that the peak flow rate in Vance Creek coincided with the peak flow rate of the flood event. The Vance Creek drainage area covers 25 square miles and was assumed to have hydrologic characteristics similar to the McTaggert Creek drainage area downstream of Lower Cushman Dam. The peak flow unit runoff value for the McTaggart Creek drainage was estimated at 280 cfs/square mile. Applying this value to the 25-square-mile Vance Creek drainage area results in a peak flow rate in Vance Creek of 7,000 cfs.

The second step was to account for the small areas of the Skokomish River watershed not included in the values discussed above. The total area of the Skokomish River watershed upstream of US 101 is 227 square miles (USGS 1993). Therefore, an additional 11.5 square miles must be accounted for in the flood estimate. Since most of the 11.5 square miles is taken up by the valley and the small drainages along the valley walls, the peak flow unit runoff value for the South Fork was used to estimate this additional flow. The final estimates used for the KCM hydraulic modeling are presented in Table 6-2.

TABLE 6-2.
INITIAL CFHMP FLOW ESTIMATES FOR DECEMBER 1994 FLOOD

Drainage Basin	Estimate of Peak Flow Rate (cfs)	Estimate of Contributing Area (square miles)	Peak Flow Unit Runoff (cfs/square mile)
South Fork	20,000	76	260
North Fork -Regulated (above dam)	87	99	----
North Fork - Unregulated (below dam)	4,413	15.5	280
Vance Creek	7,000	25	280
Valley	3,000	11.5	260
TOTAL	**34,500**	**227**	

Tacoma Public Utilities Flow Measurements for December 1994 Event

Tacoma Public Utilities (TPU) conducted two flow measurements on the Skokomish River during the morning of December 20 at the SR 106 bridge opening, the first between 8:30 and 10:47 AM, and the second between 2:33 and 3:27 PM. Although the peak of the flood event occurred at approximately 4:30 AM, these measurements, 4 to 6 hours after the flood peaks, provided an independent check on the provisional values from USGS and the estimated values developed for the CFHMP.

At the time TPU measured the flow through the SR 106 bridge opening, there was overflow onto the roadway on both sides of the bridge opening. TPU obtained approximate

measurements for the width and depth of the overflow on both sides of the bridge during the morning measurement, and calculated these discharges based on hydraulic relations for weirs. The results are shown in Table 6-3.

TABLE 6-3.
TPU FLOW ESTIMATES AT SR 106 BRIDGE FOR DECEMBER 1994 FLOOD

Time of Measurement	Flow through Bridge Opening (cfs)	Left Overbank (cfs)	Right Overbank (cfs)	Total (cfs)
8:30 to 10:47 AM	25,500	5,500	800	31,800

Final CFHMP Flow Estimates for December 1994 Event

The flow estimates used in calibration of the hydraulic model were based on data provided by the USGS and flows calculated for this CFHMP as described above. Peak flow rates in Vance Creek, the South Fork Skokomish, and North Fork Skokomish were all required. All the values are provisional estimates of what actually occurred on December 20, 1994, but, given the lack of measured data, they are the best data available. Table 6-4 presents a comparison of the flow rates from the CFHMP, USGS, and TPU. The comparison provides further justification for using the final set of values developed for this CFHMP.

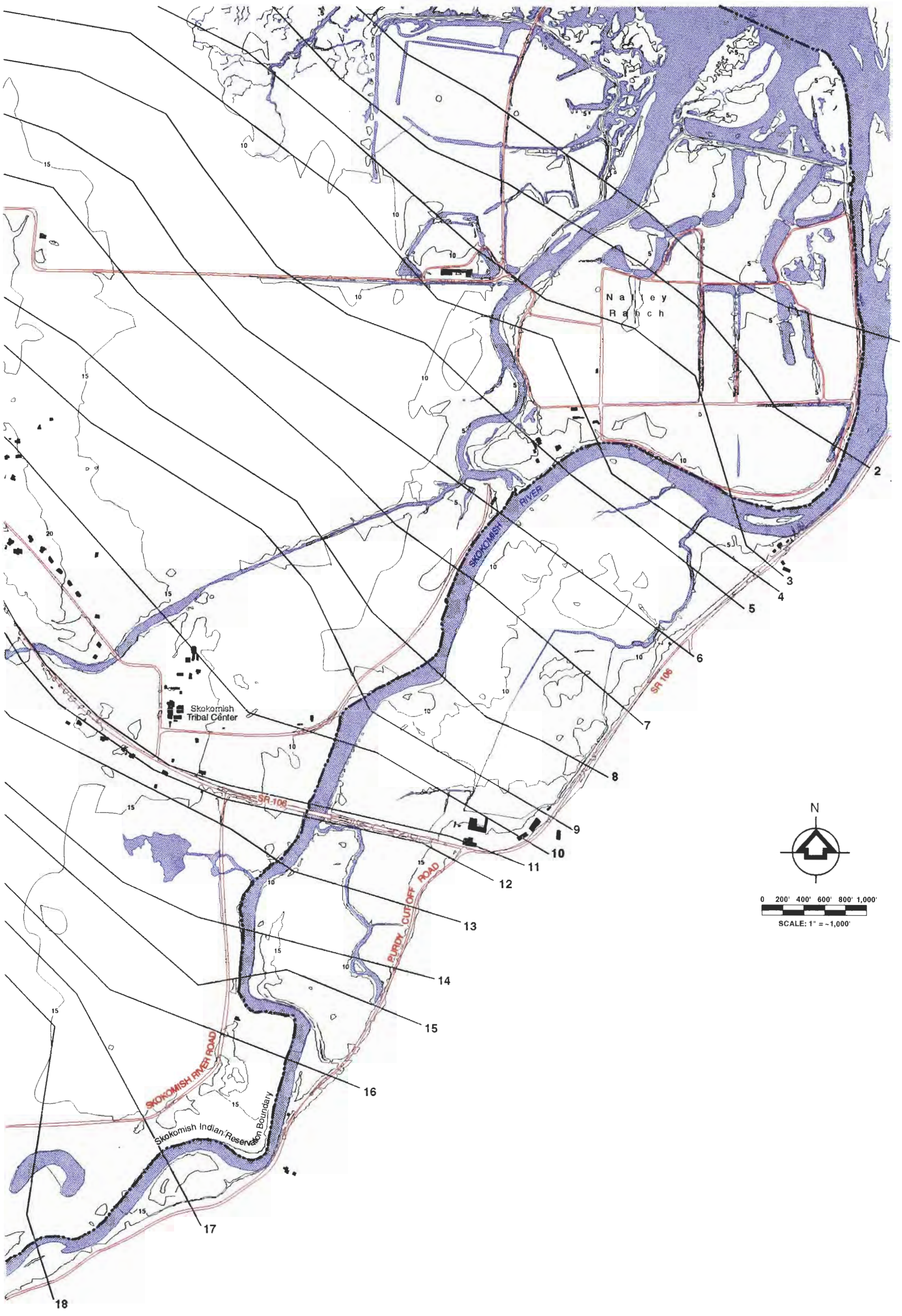
TABLE 6-4.
COMPARISON OF FLOW ESTIMATES FOR DECEMBER 1994 FLOOD

Source	Valley Tribs.	Vance Creek	North Fork Skokomish	South Fork Skokomish	Skokomish River at US 101	Skokomish River at SR 106	Comments
USGS	-----	-----	4,500	20,000	30,000 to 32,000	-----	Peak flow
CFHMP	3,000	7,000	4,500	20,000	34,500	-----	Peak flow
TPU	-----	-----	-----	-----	-----	31,800	Approx. 4-6 hours after peak flow

Calibration Analysis Input and Results

The existing conditions topography mapped by Walker and Associates in 1994 was used in the HEC-2 model for the calibration analysis. All dikes in the valley included in the map coverage were included in the calibration analysis. Reductions of large-scale topographic mapping used for the analysis are presented in Figures 6-1a through 6-1d, which also show the locations of HEC-2 cross sections.

Because of the existing hydraulic characteristics of the Skokomish River Valley, five distinct HEC-2 models were used to describe the hydraulics and the topography of the valley. The HEC-2 models were set up with overlapping sections, so that computed water surface elevations from a downstream model could be used as starting water surface elevations for the



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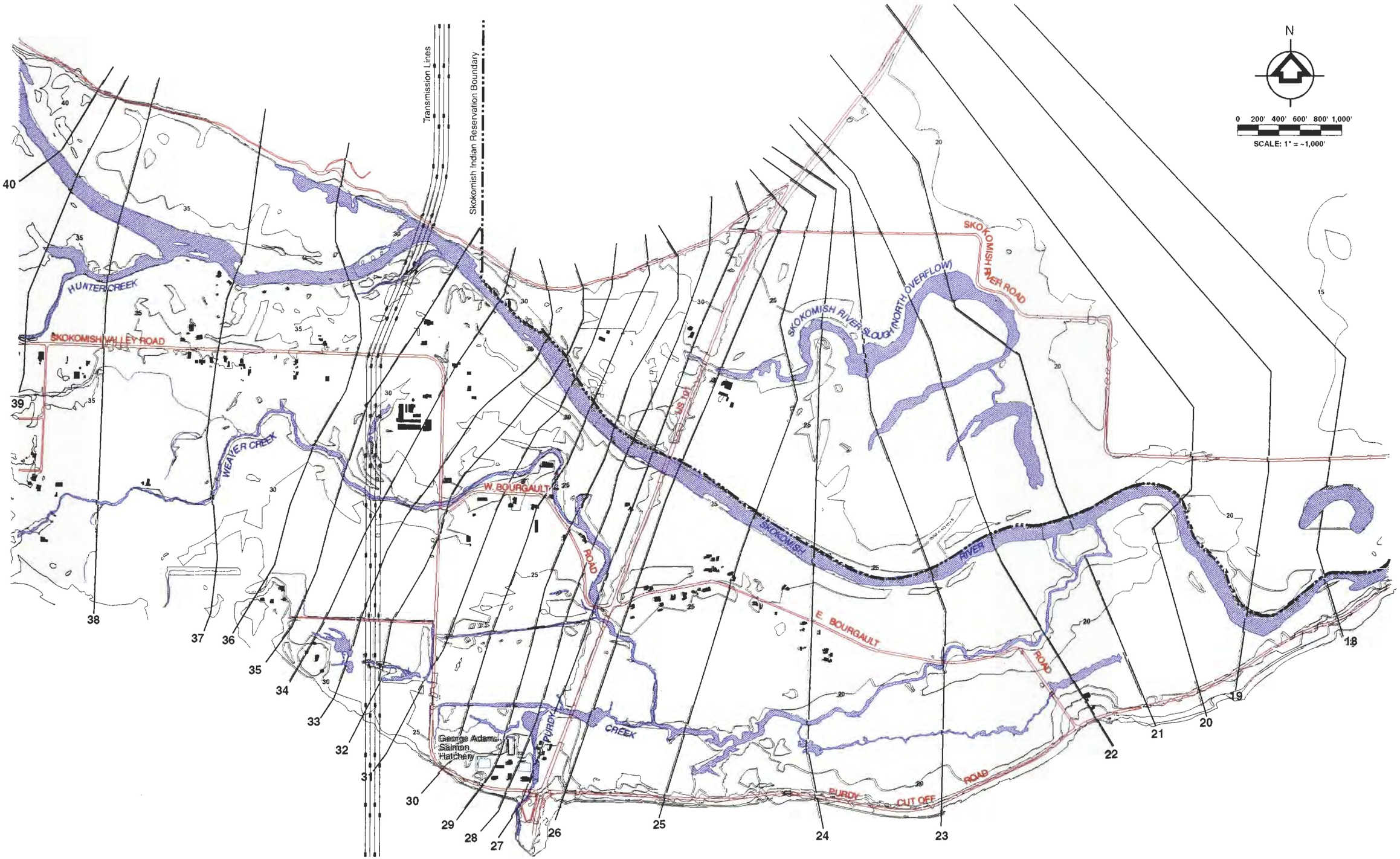
SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 6-1a.
TOPOGRAPHY AND HEC-2 CROSS-SECTIONS OF THE SKOKOMISH VALLEY—RIVER MOUTH/RESERVATION VICINITY



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HAZARD MANAGEMENT PLAN

Figure 6-1b.
TOPOGRAPHIC MAP OF THE SKOKOMISH VALLEY—
WEAVER/PURDY CREEK VICINITY

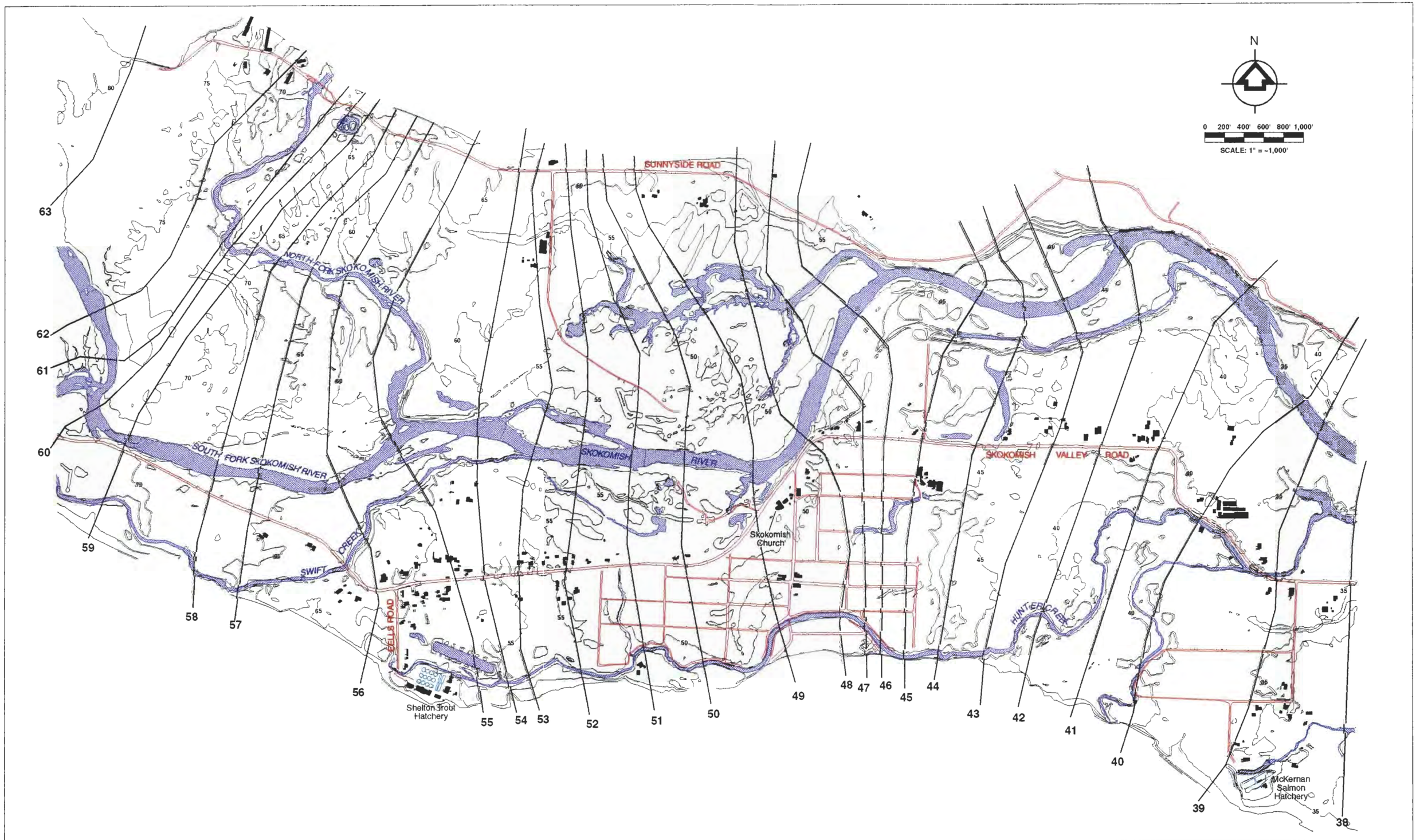

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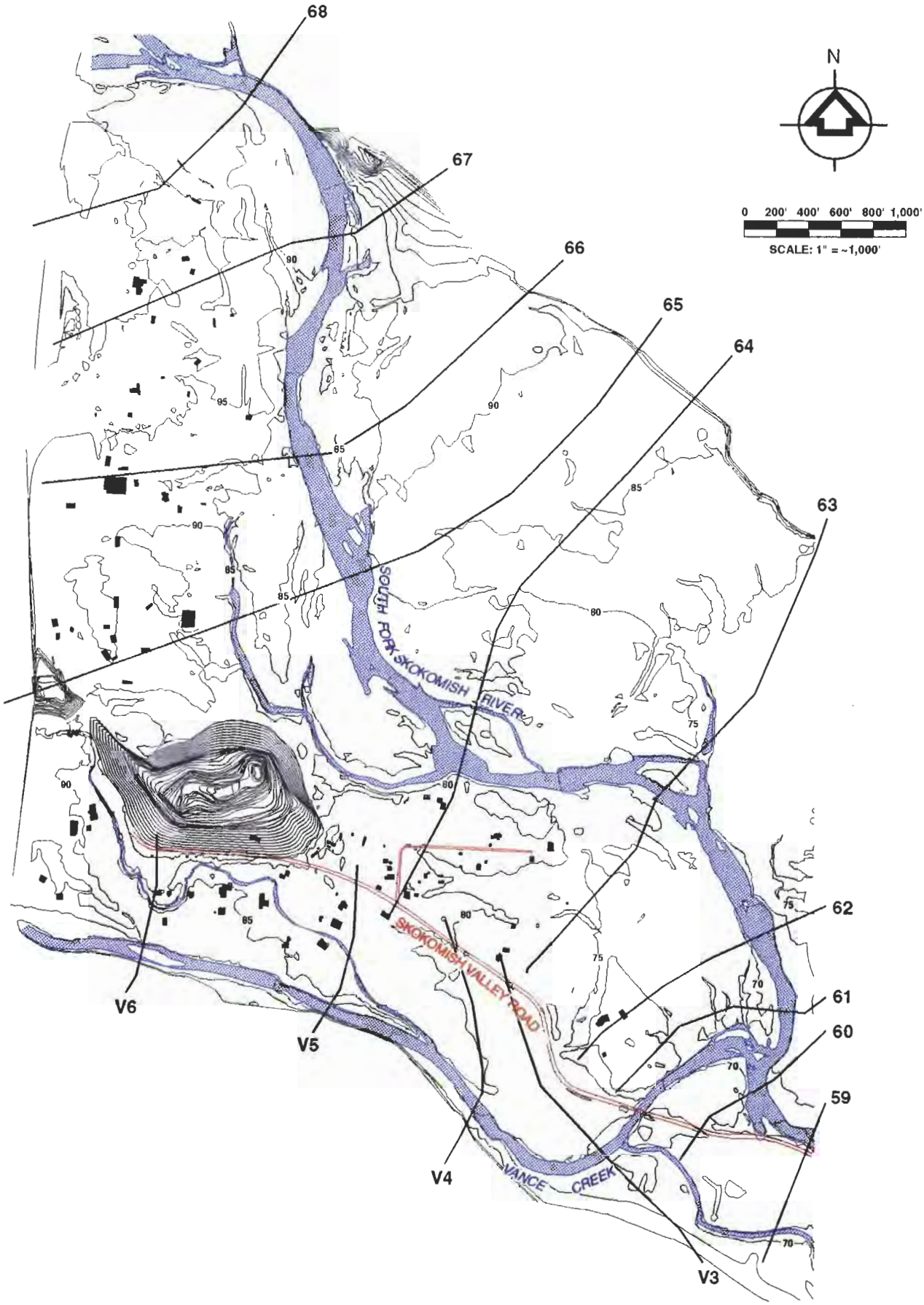
Figure 6-1c.
TOPOGRAPHY AND HEC-2 CROSS-SECTIONS OF THE
SKOKOMISH VALLEY—HUNTER CREEK VICINITY



KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-1d. TOPOGRAPHIC MAP OF THE SKOKOMISH VALLEY—FIVE MILE CORNER/ VANCE CREEK VICINITY

upstream model. Moving upstream from Annas Bay, the upstream and downstream limits of each of the existing conditions models are as follows:

- Delta Region—Left and Right Channels: The Nalley Dikes form a ring around the Nalley Farms in the Delta Region immediately upstream of Annas Bay. Two conveyance channels break off from the mainstem of the Skokomish River at RM 1.32, conveying flows on either side of the farms. The right channel currently appears to be the main channel. For the calibration run, two HEC-2 models were created to compute water surface elevations in the right and left channels from Annas Bay to River Mile 1.32. The starting water surface elevation for both models was assumed to be 9.90 (NAVD 88) based on a review of the tide charts for December 20, 1994.
- Mainstem—Downstream of US 101: A third HEC-2 file was used to compute water surface elevations from RM 1.32 up to a point immediately downstream of US 101. The starting water surface elevation for this model was the water surface elevation at Section 5 computed in the preceding HEC-2 analysis. Results from this model are used to map the floodplain from Section 5 through Section 26. The SR 106 bridge is between Section 11 and Section 12.
- Bridge Analysis: A fourth HEC-2 file was used to analyze the flow through the four bridge openings in US 101. The tributary flow option of the HEC-2 program was used to analyze each of the bridge openings independently. The bridges, from north to south, are known as the Skokomish River Slough Bridge (North Overflow Bridge), the Main Channel Bridge, the Weaver Creek Bridge, and the Purdy Creek Bridge. Each of the four bridge openings had its own data set to compute water surface elevations upstream and downstream of the opening and through the opening itself.

  The total flow rate being modeled was divided between the four tributaries, and an iterative approach was used to determine the quantity of flow through each of the openings so that the computed water surface elevation for the tributaries is equal at Section 31. This section was chosen because velocity vectors across the valley are approximately parallel at this section. This was not the case closer to the bridge openings, where overflow from one opening is conveyed to an adjacent opening, resulting in more complicated velocity distributions. The water surface elevation thus computed at Section 31 was used for the next upstream model.
- Mainstem—Upstream of US 101: A fifth HEC-2 file was used to compute the water surface elevations from just upstream of US 101 to South Fork RM 2.4. This file also includes an analysis of the downstream 4,500 feet of Vance Creek. The starting water surface elevation for this file was the computed water surface elevation at Cross-section 31 from the bridge analysis file.

The Mason County Department of Public Works surveyed 17 high-water marks following the December 1994 flood, which were also used to calibrate the HEC-2 model. Each of the five models was calibrated independently through adjustment of model parameters (roughness coefficient and ineffective flow area). In the bridge analysis, the flow distribution through each of the four openings was also adjusted. For the calibration, only the December 20, 1994, event was run. The estimated 34,500 cfs flow rate for this event is 500 cfs less than the FEMA 100-

year flood event. With one exception, all calibration points were within 0.5-foot of observed high-water marks for the flood.

Initial Computer Runs

Three initial simulations (runs) were completed using the calibrated model. The first two runs, an existing conditions simulation and a "no-dikes" simulation, were completed to provide base cases by which other alternatives could be compared. The third run was used to evaluate the capacity of the channel.

Existing Conditions Analysis

Once the HEC-2 model was calibrated to a known flood event, a series of flood events were simulated using the FEMA flood discharge values, presented in the 1988 Mason County Flood Insurance Study, and the existing valley topography. The total flow rate at the US 101 bridge location for each synthetic flood event was obtained from the Flood Insurance Study. The total flow rate was divided into four categories for each flood event, each category representing a tributary of the mainstem of the Skokomish River. The flow rates used in the existing conditions analysis are presented in Table 6-5.

TABLE 6-5.
FLOW RATES USED IN THE EXISTING CONDITIONS ANALYSIS

Location	100-Year Flow Rate (cfs)	50-Year Flow Rate (cfs)	10- Year Flow Rate (cfs)
South Fork	20,250	18,500	14,350
North Fork	4,550	4,150	3,220
Vance Creek	7,050	6,440	5,000
Valley Tributaries	3,060	2,800	2,180
Total	34,910	31,890	24,750

The HEC-2 models for the existing conditions analysis were set up as for the calibration analysis. Five models were used to simulate four different reaches of the river system. As with the calibration analysis, upstream models used results from downstream models as input. The maximum high tide of record since 1981 was used as the starting water surface elevation for the models from Annas Bay to RM 1.32. The highest high tide at the Union station on Hood Canal since 1981 is 7.43 (NGVD29) or 10.90 (NAVD88); the mapping and the modeling for this project were based on the NAVD88 datum, so the 10.90-foot high tide elevation was used.

The topography and roughness coefficients used for the existing conditions models were identical to those in the calibration models. The only differences between the two analyses were the flow rates and the tidal elevations.

One of the major topographical features of the Skokomish River Valley is the levee constructed along the south side of the river from the Swift Creek Bridge to the midsection of the Hunter Christmas tree field. Prior to the peak of the December 20, 1994, flood event, this levee was breached in at least five locations, and flood waters also circumvented its upstream end. As a

result, flood waters were conveyed on both sides of the levee. Therefore, the modeling of the calibration event assumed that flood waters were conveyed on both sides of the levee system. The same assumption was made for the 100-, 50-, and 10-year synthetic FEMA flood events, based on the following:

- The computed water surface elevations upstream of the Swift Creek Bridge were high enough to circumvent the upstream side of the levee, allowing floodwaters on both sides of the levee. This was supported by the HEC-2 modeling.
- At four other locations in the levee system, as identified in the March 1994 topographic maps, floodwaters with a frequency greater than or equal to a 10-year frequency can flow to the south side of the levees. This was also supported by the HEC-2 modeling. These locations are either old, unrepaired levee breaches, or segments of the levee unfinished due to the piecemeal construction process.
- No construction or modification done to the existing levee system lends to the conclusion that the levees could structurally withstand another major flood event without failing as they did during the December 20, 1994, flood event. It is known that the existing levee system was not constructed according to structural and geotechnical design and construction standards. This also supports the assertion that the existing levee system has at least as much chance of failing during a future major flood event as during the December 20, 1994, flood event.

No-Dike Alternative Analysis

Removal of existing dikes was the first flood hazard management alternative analyzed using the calibrated HEC-2 models. This alternative quantified the effect of existing dikes on flood levels, in addition to providing a base case against which other alternatives could be compared.

The first step in modeling this alternative was to identify the dikes to be removed. During the conceptual phase of this alternative, the Planning Advisory Committee (PAC) wondered if only official dikes should be removed, or should the definition of dike extend to any structure that serves a diking function, such as road fills, log jams, and construction fills in the floodplain. The Skokomish FCZDAC compiled a list of 21 diking structures and structures that serve a diking function in the Skokomish Valley. The following structures were included in the list:

- Approach to Vance Creek Bridge—Upper Valley—9,000 yards of fill material hauled in
- Log jam on Vance Creek behind Steve Hill's property (formerly Dugger farm)
- Dike along Vance Creek beginning behind Pat Carney's property and extending east to midsection of Herb Baze's Scottish Highlander's pasture field
- Fill on county road over culvert at northeast corner of Baze's property
- Slide on hillside, which blocked Vance Creek and caused it to cut across the county road where Vance Creek bridge is now located

- Dike at the dips back in the woods running parallel to hillside and county road
- Approaches to Swift Creek Bridge on county road
- Fill on Eells Hill Road on valley floor where washout occurred during December 1994 flood
- Log jam in river channel behind Systma place (about 1/4 mile upriver from fire hall)
- Fill on county road over culvert—Shawn Johnson's property
- Slide off hill and debris jam on Hunter Creek near Hunter-Johnson property line
- Fill on county road over culvert—Ida Johnson's property (adjacent to fire hall)
- Fill on Deyette Road
- Fill material at McKernan Salmon Hatchery and fill for road leading to hatchery from Deyette Road
- Cattle mound—Hunter Farm (formerly JX Farm)
- George Adams Salmon Hatchery—20,000 yards of fill material on west end, thousands more comprising main section of hatchery. Also, fill for road along north side of hatchery site
- Log jam on island—middle of Skokomish River upstream from US 101 bridge
- US 101 embankment
- Approaches to bridge on East Bourgault Road
- SR 106 embankment from Hunters Farm to SR 106 bridge
- SR 106 fill from bridge through Skokomish Reservation

At the March 30, 1995, meeting of the PAC, KCM was given authorization to decide which items on the list should be removed from the model in the no-dike alternative. KCM was directed to remove all the dikes identified in the 1993 Draft CFHMP in addition to all other significant structures identified on the FCZDAC's list. It was also decided that the US 101 Bridge embankment and the SR 106 embankment would not be removed.

Such items as the logjam behind the Systma Place and the slide and debris jam on Hunter Creek near the Hunter-Johnson property line were not removed for the no-dike alternative, primarily because many of these items are not prominent enough to show up on the topographic mapping, and so did not even appear in the topographic representation in the HEC-2 model.

The same 100-, 50-, and 10-year flood discharges were used for the no-dike analysis as for the existing conditions analysis; the tidal elevations were also the same. One difference between the two analyses was in the reach from Annas Bay to RM 1.32. In the existing conditions analysis, the Nalley Dikes created two channels in the delta region, necessitating the use of two HEC-2 models. Since the no-dike alternative assumed that the Nalley Dikes were removed, only one HEC-2 model was necessary at this location.

Comparison of Results from Existing Conditions and No-Dike Scenarios

A comparison of the results of the existing conditions and no-dikes simulations for the 100-year flood at selected cross-sections is shown in Figures 6-2a through 6-2d. The results indicate that the dikes have little influence on water surface elevations above SR 106. This is because water flows on both sides of the dikes during most flood events, either because water flows around the dikes or because the dikes breach during major floods. In addition, the volume of the dikes is so small compared to that of the floodplain that very little water is displaced.

In contrast, the dikes at the Nalley Farm near the mouth of the river have a dramatic effect on flood levels. The water surface elevation at the upstream end of the dike is predicted to decrease 3.6 feet if the dikes were removed. However, the reduction in flood levels resulting from removal of the dikes in this area does not extend upstream.

While the effect of the dikes on flood levels may be minimal, it should be understood that this conclusion is valid only for the specific events simulated and times within the events when the peak occurs. Prior to the flood peak, dikes can have an effect on flood levels as illustrated in the following flood sequencing:

- As flow in the river increases, and prior to flow through any new or existing levee breaks or overflows, water is contained within the channel.
- As the river rises, water begins to flow through existing breaks, creates new breaks, or overflows the levee at low points. Water levels within the levee are higher than water levels outside the levee, and flows into the non-leveed area create hazards to residents along overbank flowpaths.
- As the flow tops the levees, the water on the two sides of the levees approaches the same level. At the peak of the flood event, the water levels are roughly equal and the displacement effect is so minimal that the levees can be said to have no effect on increasing flood levels.

The existing conditions and no-dikes simulations provide information on the final stage of a flood sequence only. Additional discussion of the effects of dikes on flood levels is presented in Issue 8 below.

Channel Capacity Analysis

A channel capacity analysis was completed in order to determine how much water the channel can convey before it overflows its banks. The analysis was also completed to develop a base case for comparison with other flood hazard management alternatives. For instance, any structural modifications to the river channel, such as side-channel clearing or gravel removal, will affect the conveyance capacity of the flow corridor. Therefore, the improved flow corridor capacity under one of these structural modification scenarios can be compared to the existing conditions flow corridor capacity to determine the hydraulic effectiveness of the alternative.

The first step in the analysis was to determine the approximate alignment of the high ground of the overbanks. This is generally defined as the ground elevation along the overbanks that, if exceeded, would allow flood waters to be conveyed into the floodplain. A mosaic was prepared from a set of 1:200 scale topographic maps to form a continuous large-scale map of the

river channel and the immediate overbanks. A continuous line was drawn connecting the high ground along the right and left overbanks (looking downstream) from the confluence of the South and North Forks to East Bourgault Road. Most of the line along the left overbank corresponded to the north valley wall due to its proximity to the river. Once the high ground line was delineated, high ground elevation points at each HEC-2 cross-section were tabulated.

The high ground of the left and right overbanks defined a flow corridor shown in Figures 6-3a through 6-3c. Flood flows contained within this flow corridor would cause no damage to structures or roadways. Flood flows exceeding the conveyance capacity of the flow corridor would flow onto the floodplain, potentially resulting in damage to structures and roadways.

The flow corridor was modified in certain sections to facilitate later completion of a berm analysis (see Issue 8) and comparison of alternatives. A berm alignment was drawn, generally corresponding with the high ground along the right and left overbanks, but shifted from the high ground in some areas to produce a smooth alignment or to ensure that existing structures were outside the alignment.

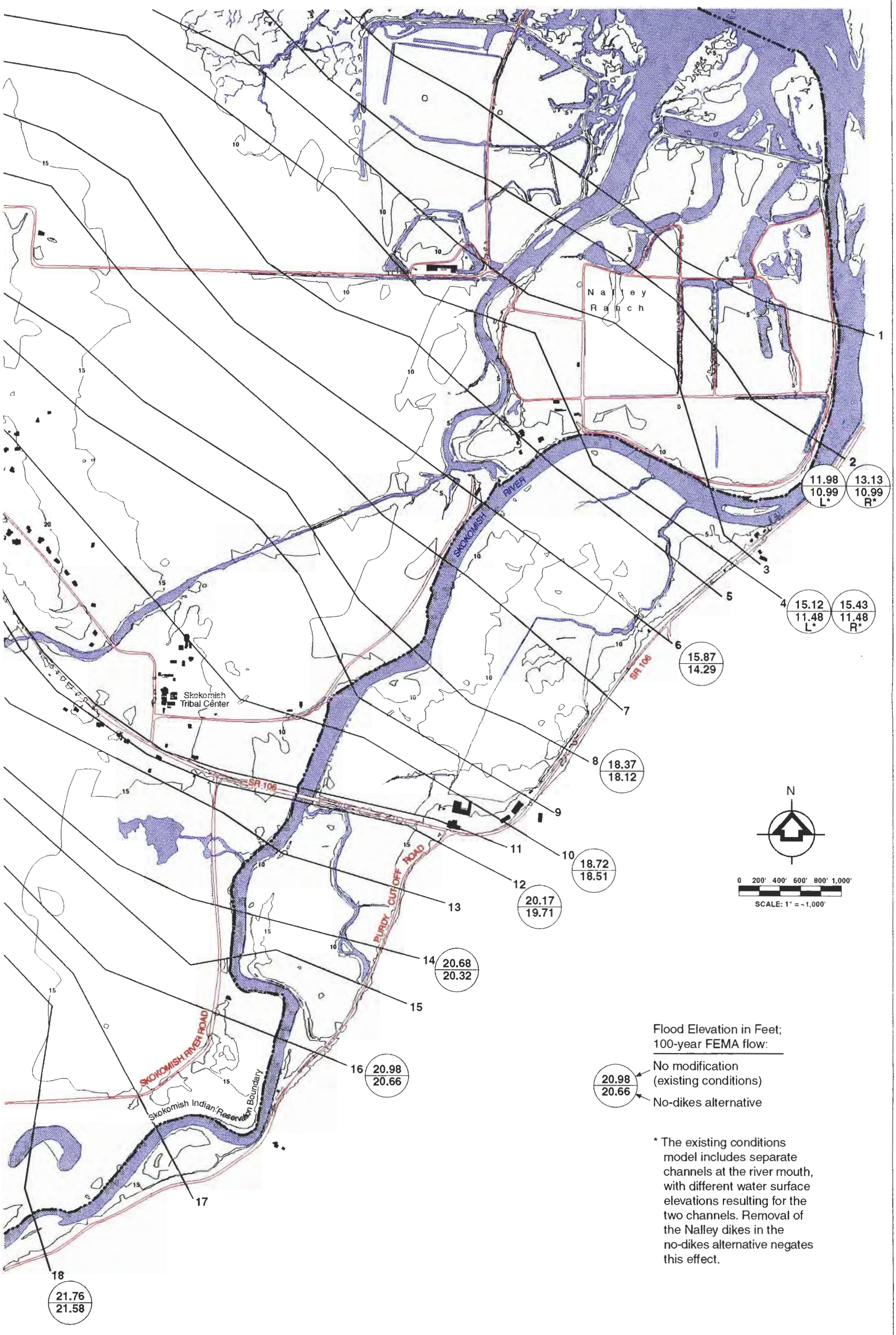
A HEC-2 model was then developed to analyze the flow corridor. The model developed for the no-dikes analysis was adopted for this analysis. Simulations were run for flow rates ranging from 4,000 cfs to the 5-year flood of 21,500 cfs.

The modeling produced a series of water surface elevations for the different flow rates at each of the modeled sections. The capacity of the channel at each cross-section was then determined by comparing the water surface elevations and corresponding flows with the high ground elevations at each cross-section. The flow that produced a stage equaling the high ground elevation was recorded as the capacity of the channel at that cross-section. Greater flows would result in water flowing over the adjacent high ground and inundating the adjacent floodplain.

Table 6-6 lists water surface elevations and flows for each cross-section. Figures 6-3a through 6-3c show the flow corridors at each cross-section. Channel capacities at cross-sections are also presented in Table 6-7. The average capacity of the river channel for the reach between US 101 and the confluence of the North and South Forks is approximately 8,000 cfs. This is approximately one-half and one-quarter of the discharge expected during the 100-year and 2-year floods in this reach, respectively. River capacities at specific cross-sections range from less than 4,000 to more than 21,500 cfs.

The channel capacity is low at several locations. Places where channel capacity is low in one cross-section but much higher in the next cross-section downstream are preferred for alternatives that increase conveyance capacity. These bottlenecks cause out-of-bank flows even when it is possible to convey these flows through downstream channel sections. In Sections 52 through 54 and 56, for instance, the channel capacity is under 4,000 cfs, but downstream cross-sections can convey 12,500 to 20,500 cfs.

The analysis was predicated on constraining all flow to a limited flow corridor. This assumption was made so that comparisons could be made with alternatives that involve alteration of the channel. In reality, flood waters may leave the channel at an upstream point and never re-enter the channel.



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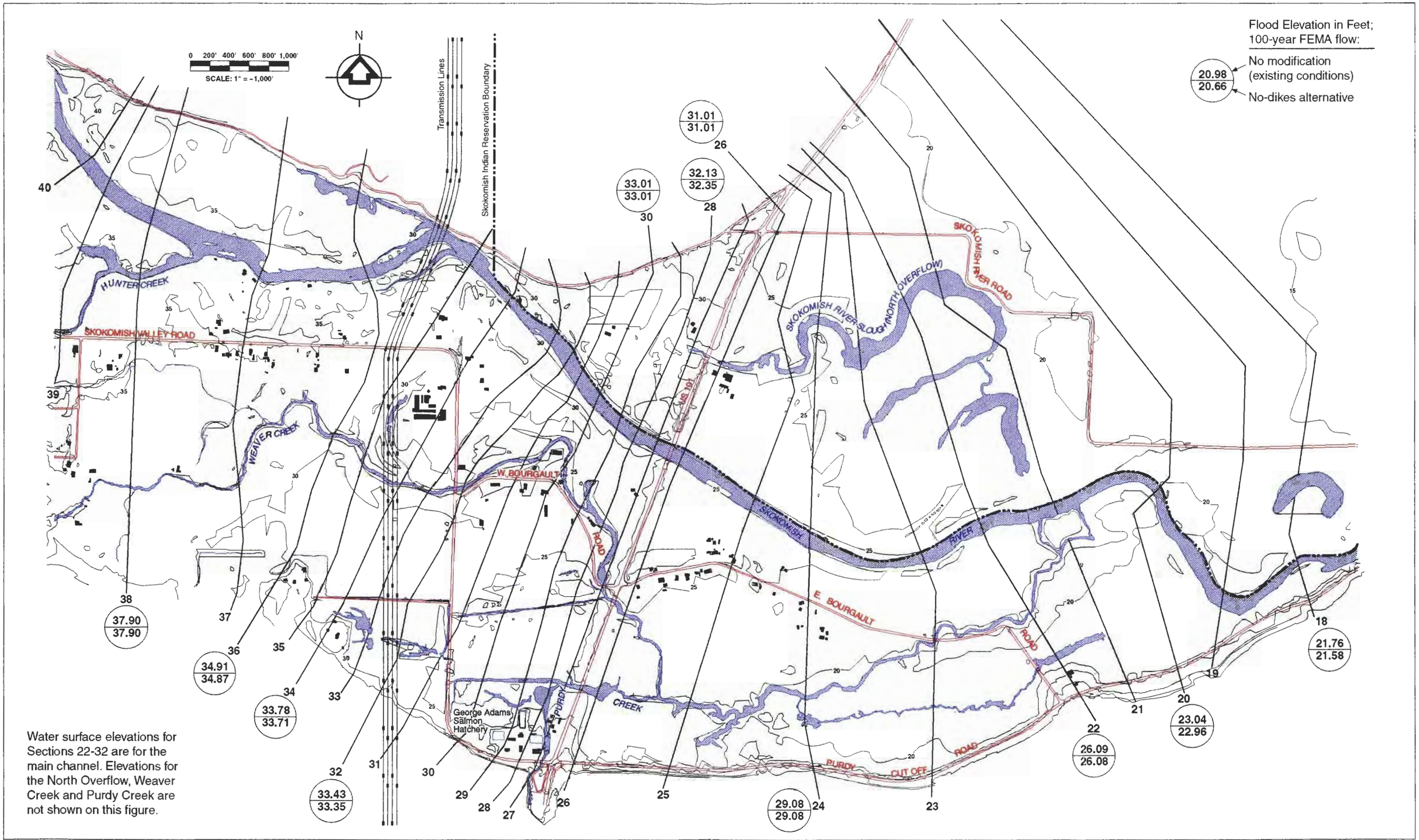
SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 6-2a.
PREDICTED 100-YEAR FLOOD WATER SURFACE ELEVATIONS—RIVER MOUTH/RESERVATION VICINITY



Water surface elevations for Sections 22-32 are for the main channel. Elevations for the North Overflow, Weaver Creek and Purdy Creek are not shown on this figure.

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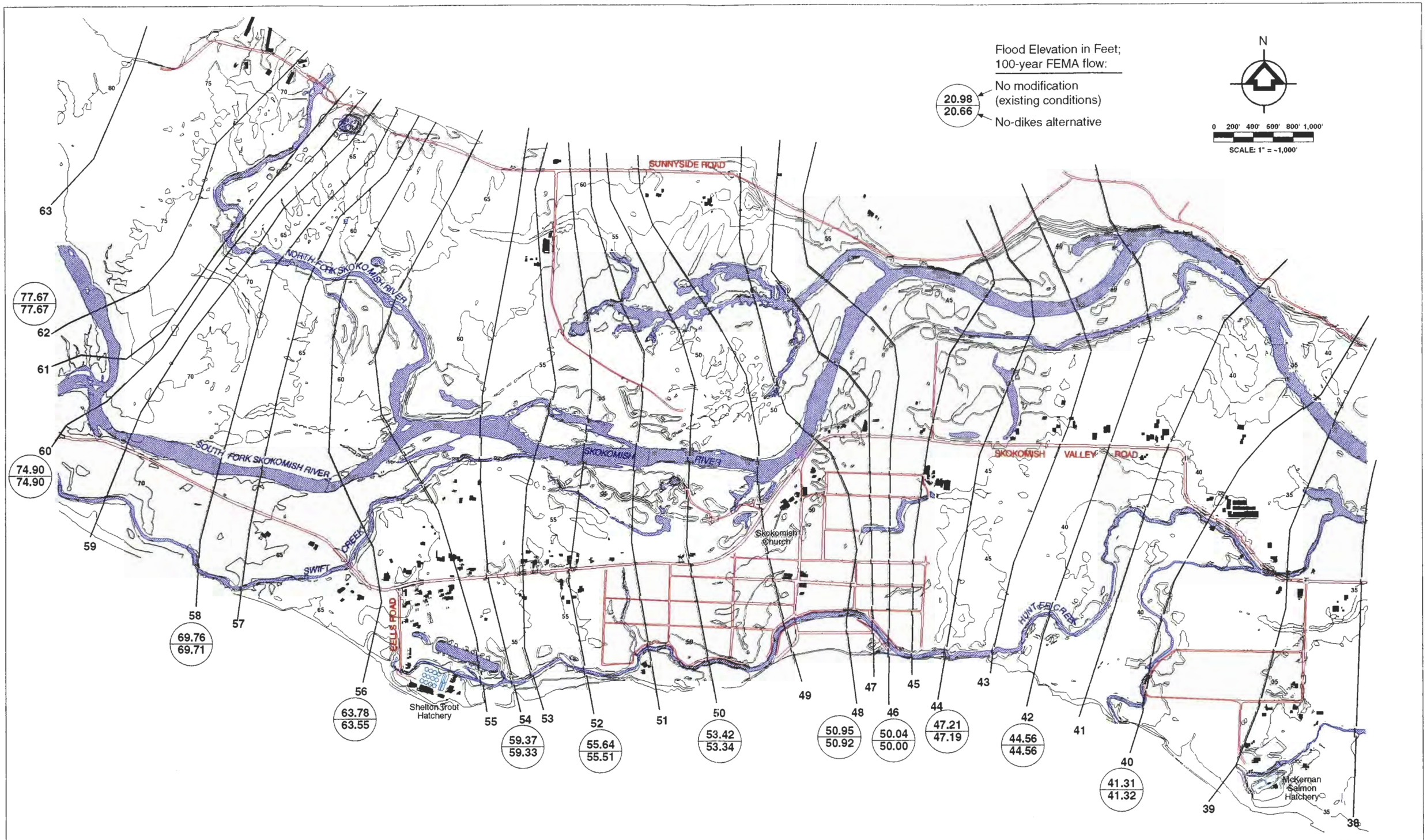
HAZARD MANAGEMENT PLAN

Figure 6-2b.
PREDICTED 100-YEAR FLOOD WATER SURFACE ELEVATIONS—
WEAVER/PURDY CREEK VICINITY



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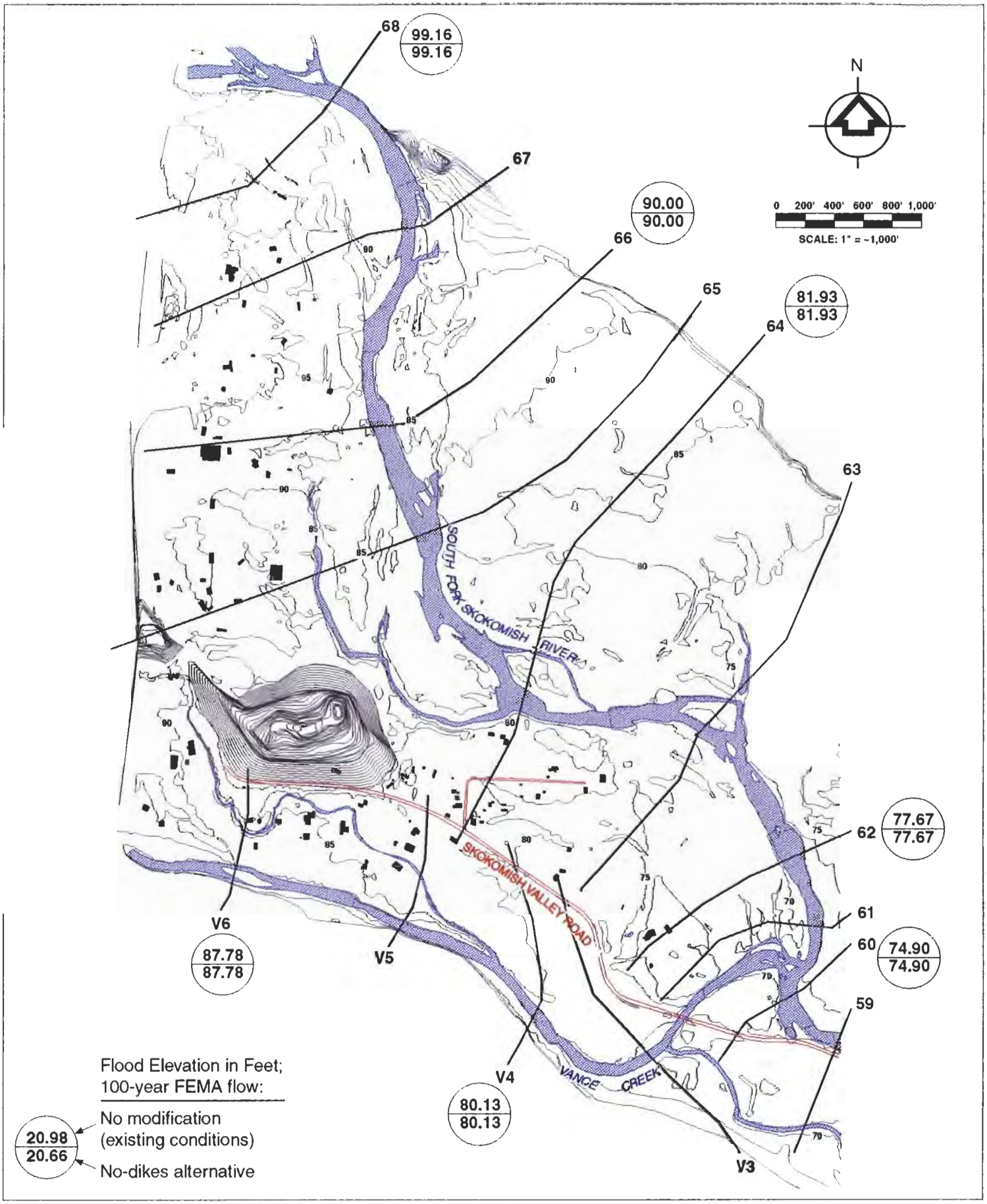
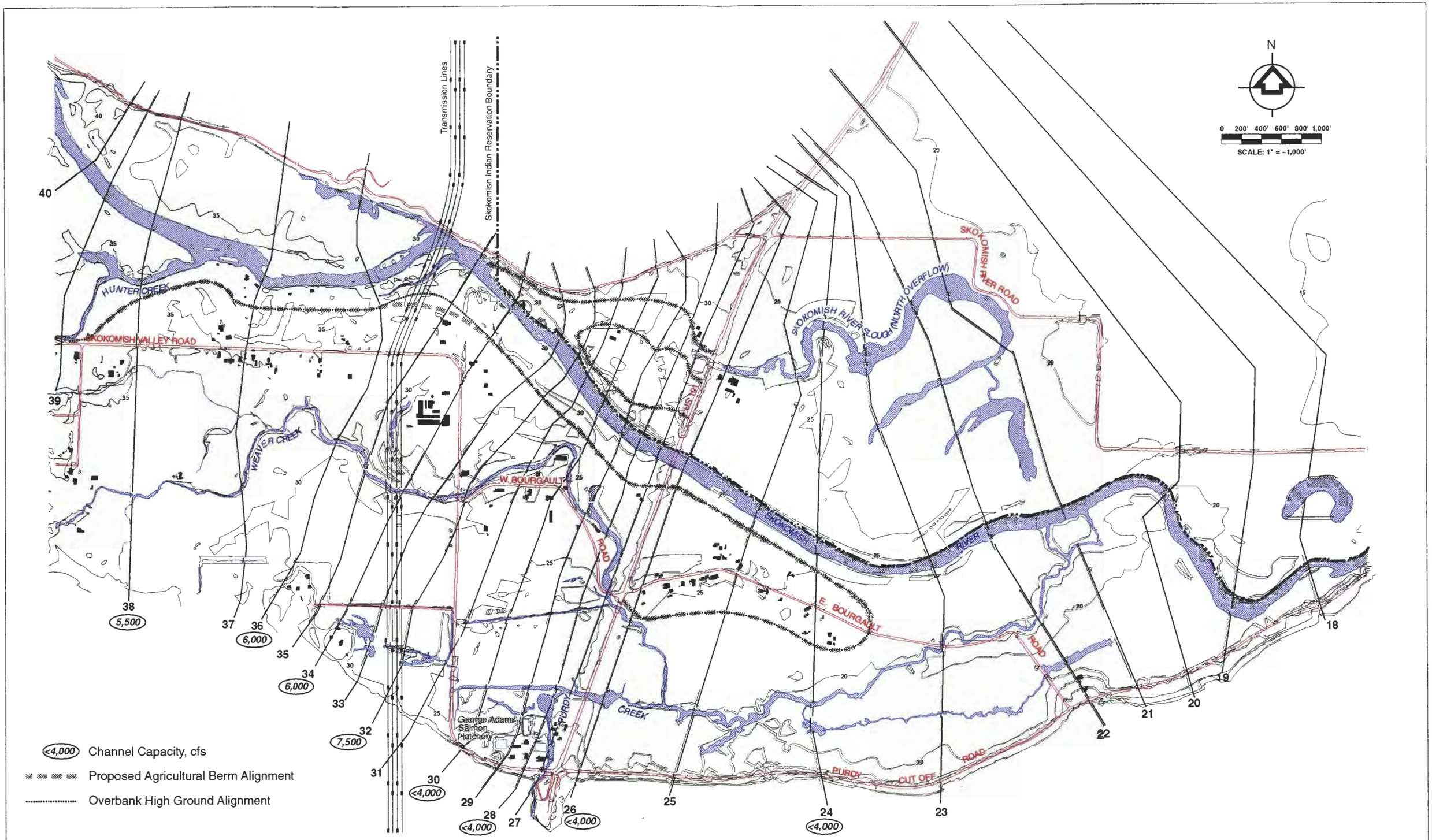
HAZARD MANAGEMENT PLAN

Figure 6-2c.
PREDICTED 100-YEAR FLOOD WATER SURFACE ELEVATIONS—
HUNTER CREEK VICINITY



KCM 1917 First Avenue Seattle, Washington 98101	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-2d. PREDICTED 100-YEAR FLOOD WATER SURFACE ELEVATIONS— FIVE MILE CORNER/VANCE CREEK VICINITY



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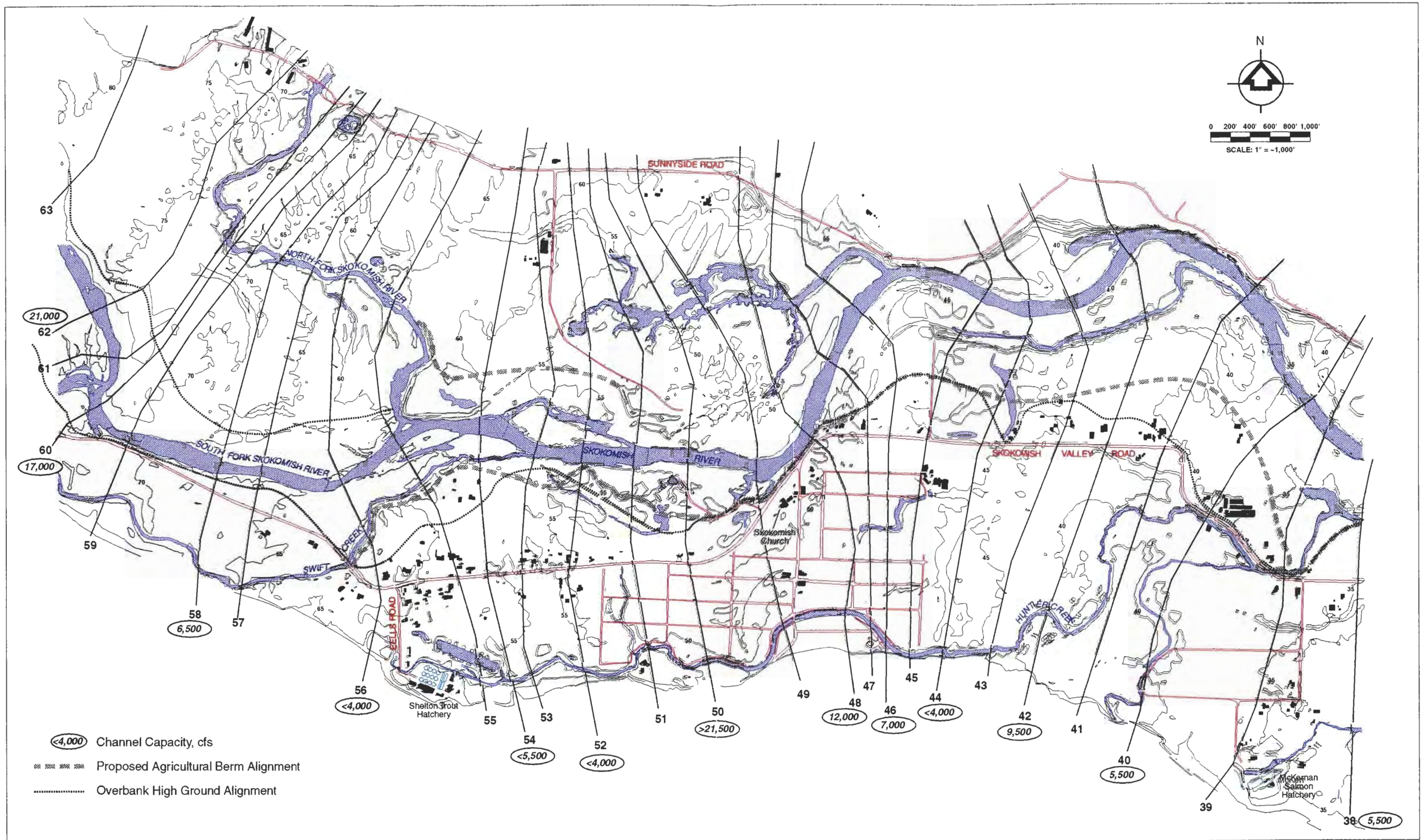
HAZARD MANAGEMENT PLAN

Figure 6-3a.
CHANNEL CAPACITY—
WEAVER/PURDY CREEK VICINITY



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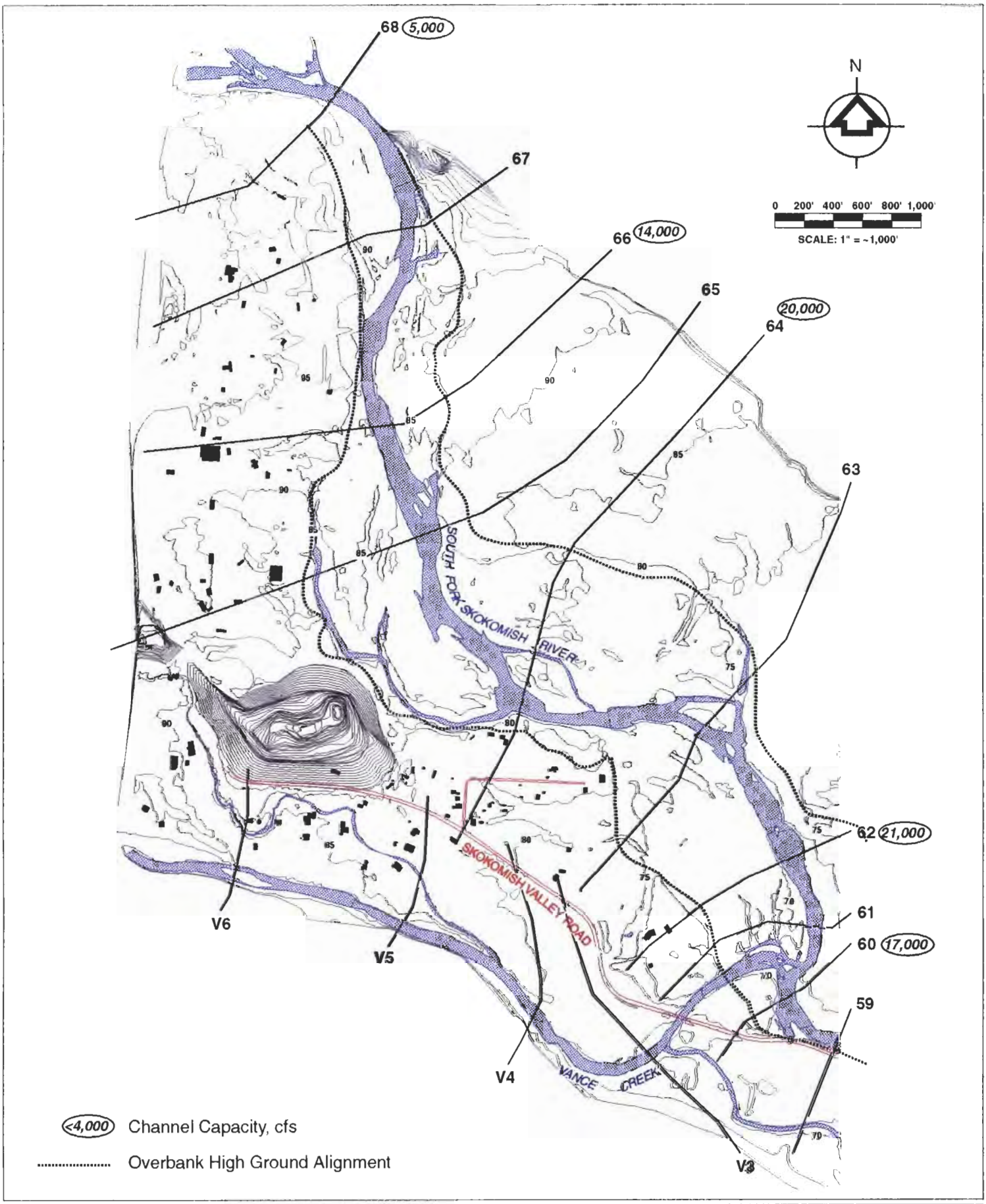
HAZARD MANAGEMENT PLAN

Figure 6-3b.
CHANNEL CAPACITY—HUNTER CREEK VICINITY



KCM 1917 First Avenue Seattle, Washington 98101	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-3c. CHANNEL CAPACITY—FIVE MILE CORNER/ VANCE CREEK VICINITY

TABLE 6-6.
PREDICTED WATER SURFACE ELEVATIONS UNDER EXISTING CONDITIONS WITH NO DIKES

		4,000 cfs		6,000 cfs		10,000 cfs		16,200 cfs		21,500 cfs		
HEC-2 Cross Section Number	Overbank Ground Elevation	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Approximate Channel Capacity
24	24.4	26.01	1.61	26.71	2.31	27.47	3.07	28.41	4.01	29.05	4.65	< 4,000
25	26.6	26.72	0.12	27.43	0.83	28.28	1.68	29.25	2.65	29.95	3.35	4,000
26	28.1	28.43	0.33	29.47	1.37	30.61	2.51	31.76	3.66	32.58	4.48	< 4,000
27 - L	33.0	28.60		29.66		31.09		32.61		33.71	0.71	
27 - R	28.0	28.60	0.60	29.66	1.66	31.09	3.09	32.61	4.61	33.71	5.71	< 4,000
overflow L	33.4					29.11		30.94		31.92		
overflow R	31.2					29.11		30.94		31.92	0.72	
28 - L	30.0	28.76		29.87		31.27	1.27	32.76	2.76	33.85	3.85	
28 - R	28.4	28.76	0.36	29.87	1.47	31.27	2.87	32.76	4.36	33.85	5.45	< 4,000
overflow L	32.5					30.02		31.93		33.10	0.60	
overflow R	30.5					30.02		31.93	1.43	33.10	2.60	
29 - L	30.5	28.97		30.15		31.58	1.08	33.11	2.61	34.24	3.74	
29 - R	29.0	28.97		30.15	1.15	31.58	2.58	33.11	4.11	34.24	5.24	4,000
overflow L	30.9					30.44		32.33	1.43	33.56	2.66	
overflow R	28.5					30.44	1.94	32.33	3.83	33.56	5.06	
30 - L	29.5	29.20		30.47	0.97	31.97	2.47	33.56	4.06	34.72	5.22	
30 - R	28.0	29.20	1.20	30.47	2.47	31.97	3.97	33.56	5.56	34.72	6.72	< 4,000
overflow L	32.4					30.82		32.64	0.24	33.87	1.47	
overflow R	32.1					30.82		32.64	0.54	33.87	1.77	
31 - L	30.5	29.52		30.80	0.30	32.31	1.81	33.95	3.45	35.15	4.65	
31 - R	30.3	29.52		30.80	0.50	32.31	2.01	33.95	3.65	35.15	4.85	5,000
overflow L	34.7					31.50		33.29		34.51		
overflow R	33.0					31.50		33.29	0.29	34.51	1.51	
32 - L	32.0	29.72		31.02		32.51	0.51	34.17	2.17	35.40	3.40	
32 - R	31.5	29.72		31.02		32.51	1.01	34.17	2.67	35.40	3.90	7,500
overflow L	33.9					32.52		34.18	0.28	35.39	1.49	
overflow R	32.3					32.51	0.21	34.17	1.87	35.40	3.10	
33 - L	33.3	29.81		31.13		32.64		34.30	1.00	35.51	2.21	
33 - R	31.9	29.81		31.13		32.64		34.30		35.51		8,000
34 - L	35.45	30.34		31.74		33.45		35.27		36.53	1.08	
34 - R	31.83	30.34		31.40		33.45		35.27		36.53		6,000
35	34.68	31.43		32.85		34.66		36.49	1.81	37.74	3.06	10,000
36	34.87	32.69		35.02	0.15	36.95	2.08	39.05	4.18	40.46	5.59	6,000
37	35.34	34.41		36.27	0.93	37.77	2.43	39.75	4.41	41.14	5.80	5,000
38	36.88	35.99		37.18	0.30	38.57	1.69	40.45	3.57	41.80	4.92	5,500
39	35.89	36.33	0.44	37.48	1.59	38.89	3.00	40.75	4.86	42.09	6.20	< 4,000
40	37.83	36.84		38.15	0.32	39.77	1.94	41.58	3.75	42.89	5.06	5,500
41	40.61	39.23		40.73	0.12	42.03	1.42	43.37	2.76	44.42	3.81	6,000
42	43.28	40.77		42.05		43.48	0.20	44.89	1.61	45.90	2.62	9,500
43	44.55	41.81		43.14		44.30		45.72	1.17	46.74	2.19	11,000
44	42.59	43.24	0.65	44.36	1.77	45.56	2.97	46.98	4.39	47.94	5.35	<4,000
45	46.58	43.91		44.89		46.18		47.59	1.01	48.52	1.94	12,000
46 - R	47.77	46.74		47.51		48.64	0.87	49.71	1.94	50.51	2.74	7,000
47 - R	49.21	47.62		48.40		49.57	0.36	50.66	1.45	51.34	2.13	9,000
48 - R	50.50	48.42		48.99		50.12		51.25	0.75	51.93	1.43	12,000
49 - R	50.84	48.72		49.65		50.77		51.91	1.07	52.64	1.80	10,500
50 - R	53.82	49.91		50.59		51.67		52.71		53.45		> 21,500
51 - L	53.50	52.68		53.13		53.69	0.19	54.26	0.76	54.85	1.35	
51 - R	54.75	52.68		53.13		53.69		54.26		54.85	0.10	8,500
52 - L	54.25	54.14		54.84	0.59	56.04	1.79	57.38	3.13	58.23	3.98	
52 - R	53.61	54.14	0.53	54.84		56.04		57.38		58.23		< 4,000
53 - L	53.5	55.19	1.69	55.94	2.44	57.37	3.87	58.60	5.10	59.45	5.95	
53 - R	54.99	55.19	0.20	55.94		57.37		58.60		59.45		< 4,000
54 - L	57.75	56.97		57.71		58.99	1.24	60.03	2.28	60.82		
54 - R	57.5	56.97		57.71	0.21	58.99		60.03		60.82		5,500
55 - L	61.29	58.35		59.05		60.33		61.30	0.01	62.00	0.71	
55 - R	60.76	58.35		59.05		60.33		61.30		62.00		12,500
56 - L	63.8	62.68		63.60		64.60	0.80	65.78	1.98	66.61	2.81	
56 - R	61.75	62.68	0.93	63.60		64.60		65.78		66.61		< 4,000
57 - L	68.15	64.46		65.29		66.27		67.48		68.35	0.20	
57 - R	66.40	64.46		65.29		66.27		67.48	1.08	68.35		10,500
58 - L	68.37	65.45		66.23		37.30		68.58	0.21	69.49	1.12	
58 - R	66.36	65.45		66.23		67.30		68.58		69.49		6,500
59 - L	72.35	67.13		67.95		69.29		70.83		71.69		
59 - R	69.94	67.13		67.95		69.29		70.83	0.89	71.69		12,500
60 - L	73.74	68.44		69.77		71.76		73.54		74.55	0.81	
60 - R	74.91	68.44		69.77		71.76		73.54		74.55		17,000
61 - L	76.18	70.93		71.32		72.59		74.19		75.21		
61 - R	76.27	70.93		71.32		72.59		74.19		75.21		21,500
62 - L	77.48	73.34		74.00		74.88		76.06		76.94		
62 - R	76.88	73.34		74.00		74.88		76.06		76.94	0.06	21,000
63 - L	78.0	74.81		75.54		76.61		77.81		78.75	0.75	
63 - R	78.0	74.81		75.54		76.61		77.81		78.75	0.75	17,500
64 - L	83.78	80.22		80.62		80.98		81.53		82.08		
64 - R	81.92	80.22		80.62		80.98		81.53		82.08	0.16	20,000
65 - L	88.16	83.87		84.83		86.50		88.14		88.17	0.01	
65 - R	88.2	83.87		84.83		86.50		88.14		88.17		21,500
66 - L	92.1	85.85		86.89		88.51		90.11		90.19		
66 - R	89.49	85.85		86.89		88.51		90.11	0.62	90.19	0.70	14,000
67 - L	99.76	91.31		92.18		93.12		94.16		95.24		
67 - R	95.74	91.31		92.18		93.12		94.16		95.24		> 21,500
68 - L												
68 - R	96.27	95.90		96.66	0.39	97.74		98.93		99.53		5,000

General Notes:

The capacity of the flow corridor was analyzed using HEC-2.
Depth above overbank ground column indicates height of water surface elevation above overbank high ground.
These data were used to estimate the flow capacity of the corridor.
The analysis assumes that all flow is contained strictly within the defined flow corridor.
16,200 cfs = 2 yr flood event, 21,500 cfs = 5 yr flood event

Notes on Results of analysis for sections 57-68:

No berms were proposed in this reach, but an estimate of the flow capacity of the river was desired.
A flow corridor was opened by approximate high points along the left and right overbank.

TABLE 6-7.
FLOW CORRIDOR CAPACITY (cfs)

HEC-2 Cross Section Number	Flow Corridor Capacity (cfs	HEC-2 Cross Section Number	Flow Corridor Capacity (cfs)
28	< 4,000	49	10,500
29	4,000	50	>21,500
30	< 4,000	51	8,500
31	5,000	52	< 4,000
32	7,500	53	< 4,000
33	8,000	54	5,500
34	6,000	55	12,500
35	10,000	56	< 4,000
36	6,000	57	10,500
37	5,000	58	6,500
38	5,500	59	12,500
39	<4,000	60	17,000
40	5,500	61	>21,500
41	6,000	62	21,000
42	9,500	63	17,500
43	11,000	64	20,000
44	<4,000	65	21,500
45	12,000	66	14,000
46	7,000	67	>21,500
47	9,000	68	5,000
48	12,000		

ISSUE 1: FOREST PRACTICES IN THE SOUTH FORK WATERSHED HAVE CONTRIBUTED TO SEDIMENTATION IN THE LOWER MAINSTEM, CAUSING INCREASED FLOODING

Timber harvesting has been shown to cause negative effects in other watersheds as well as the Skokomish Watershed. These effects fall into two general categories, alteration of the runoff and diminishment of water quality. Changes in the runoff regime relate to increased volumes of runoff and shorter times between rainfall and runoff peaks. The most common water quality effects are increased water temperatures and increased sediment load. Increasing the fine-grained sediment supply (silt and clay) can be detrimental to fisheries resources that depend on clean gravel beds for spawning. An increased sediment load, if substantial enough, can cause aggradation of the riverbed.

The negative impact of logging in the South Fork Watershed on the mainstem Skokomish River has been exacerbated by the operation of the Cushman Hydroelectric Project in the North Fork Watershed (see Chapter 3). The relationship between these upper watershed actions and their effects on the mainstem remains unclear. Therefore, the issues relating to forest practices and the Cushman Project are treated separately.

Alternatives in this section focus on both the South Fork Watershed and the Skokomish Valley. A discussion of South Fork Watershed restoration recommendations based on the recently

completed South Fork Watershed Analysis is presented first. Alternatives for the Skokomish Valley follow, and include two categories of action, gravel removal and riverbank stabilization.

South Fork Watershed

The South Fork Skokomish Watershed Analysis was completed in June 1995. It was a cooperative effort between the USFS and a large number of other groups and agencies, including the Skokomish Indian Tribe, U.S. Fish and Wildlife Service, and Ecology. Recommendations for the South Fork Watershed are presented in Section 4 of *Guidance for Site Analysis and Project Level Planning* (USFS 1995).

The 1993 Draft CFHMP contained a chapter summarizing the history and then-current status of logging in the basin, and describing the impact of logging on the Skokomish River. The chapter is included in its entirety as Appendix E of this report.

The Simpson Timber Company (Simpson) also plans to complete a watershed analysis for lands it owns and manages. Approximately 23 percent of the entire Skokomish River Watershed is privately owned, mostly by Simpson. During the course of development of this CFHMP, Simpson has provided details of the watershed management activities it is planning. Copies of these communications are presented in Appendix T. Simpson's planned future activities include the following:

- Watershed Analysis: A Watershed Analysis for the South Fork Skokomish Watershed Administrative Unit is scheduled for completion by February 1997
- Road Maintenance, Rehabilitation, and Abandonment Plan: Of the 73 total miles of Simpson-owned roads, 52 miles will be maintained as active, 11 miles will be permanently abandoned, 8 miles will be put in "dormancy" status, and 2 miles have already been naturally re-vegetated
- Planned Harvesting: Simpson plans to harvest 607 acres of land under current Forest Practices Permits in 1996. For the next 10 years, the planned harvest will average 188 acres per year.

South Fork Watershed: Alternatives

The CFHMP endorses the recommendations contained in the South Fork Watershed Analysis. They were developed through in-depth analysis of watershed conditions following methodologies presented in that latest state and federal guidance documents *Board Manual: Standard Methodology for Conducting Watershed Analysis* (Washington State Forest Practices Board 1992) and *A Federal Guide for Pilot Watershed Analysis* (USDA 1994). Copies of sections of the Watershed Analysis relevant to flooding and sedimentation are included with this report as Appendix U. The following is a summary of the restoration recommendations in the report.

Riparian reserves should be established based on criteria listed in the report for different categories of surface waters. Riparian reserves are "a network of corridors, closely coupled with streams and rivers including intermittent channels, wetlands and unstable areas, where riparian-dependent resources receive primary emphasis" (USFS 1995). Functions of the these riparian areas include shade for temperature moderation, a direct supply of large woody debris

for nutrient cycling and structure, streambank vegetation to moderate erosion, and deeper soils and organics that release stored subsurface water more slowly to reduce the effects of runoff.

The Watershed Analysis proposes that riparian reserve widths be maximized within the recommended federal guidelines for establishing such areas. Widths for each category of surface water are listed in Table 6-8.

TABLE 6-8.
CRITERIA FOR DEFINING INTERIM RIPARIAN RESERVES

Categories	Widths
Fish-bearing streams	Includes active stream channel to the top of the inner gorge, or to outer edges of 100-year floodplain, or outer edges of riparian vegetation or distance equal to the height of two site-potential trees, or 300 feet slope distance (600 feet total), whichever is greatest.
Permanently flowing, non-fish-bearing streams	Includes active stream channel to the top of the inner gorge, or to outer edges of 100-year floodplain, or outer edges of riparian vegetation or distance equal to the height of one site-potential trees, or 150 feet slope distance (300 feet total), whichever is greatest.
Constructed ponds, reservoirs, and wetlands larger than 1 acre	Include outer edge of vegetation, or to extent of seasonally saturated soil, or extent of unstable areas, or distance equal to height of one site-potential tree, or 150 feet slope distance from edge, whichever is greatest.
Lakes and natural ponds	Include outer edge of vegetation, or extent of seasonally saturated soil, or to the extent of unstable and potentially unstable areas, or distance equal to height of two site-potential trees, or 300 feet slope distance, whichever is greatest.
Seasonally flowing or intermittent streams, wetlands smaller than 1 acre, and unstable or potentially unstable areas	Include extent of unstable or potentially unstable areas; extend to top of inner gorge; to the outer edges of riparian vegetation; or distance equivalent to one site-potential tree, or 100 feet slope distance, whichever is greatest.

The Watershed Analysis also contains recommendations for watershed restoration in the categories of aquatic habitats, terrestrial habitats and processes including wildlife and vegetation, and sedimentation and hydrology. Restoration recommendations are made at the watershed and sub-watershed levels. The Watershed Analysis recognizes that additional restoration actions may be implemented in the future as site-specific planning and project analysis is completed.

Sedimentation

Recommendations for restoration and protection strategies relating to sedimentation are ranked by the degree of source input. Eighty-five percent of sediment sources are road-related, 10 percent come from removal of vegetation along steep drainages and accelerated surface runoff from a combination of high road densities and hydrologically immature vegetation (hydrologic maturity is discussed in below). Less than 5 percent is from in-stream bank erosion. General restoration and protection strategies proposed by USFS include the following:

- Continue sediment input reduction. Sediment inputs are one of the least complicated to address and brings immediate results. Selection of treatment sites should be based on their deliverability to a stream course or in severe cases, potential effect to soil productivity (a site's ability to sustain vegetative cover)
- Evaluate road management objectives and maintenance strategies to address sediment reduction on high sediment hazard roads
- Maintain water quality within Washington State Water Quality Standards (i.e., Class AA) which provide the highest quality of water possible under the Clean Water Act.
- Eliminate unstable sidecast with high risk of delivery to stream courses and mass wasting hazard that has high risk of delivery to stream courses.
- Full implementation of proposed Riparian Reserves is expected to lead to recovery of the natural pattern of in-channel large wood structure, sediment, and water flows
- Recover local hydrologic balance of peak flows within the watersheds and sub-watersheds.
- Reintroduction of floodplain function to the lower Skokomish founded on channel morphology and sediment budget analysis (USFS 1995).

A detailed list of existing sediment sources and sites with potential for mass-wasting from unstable sidecast is included as an appendix to the Watershed Analysis. Cause, condition or trend, relative size, and proposed treatment for each sediment source are included. Treatments are listed as follows:

- Clean culverts
- Truck hydromulch
- Erosion matting
- Fill pullback
- Aerial hydromulch
- Distribute straw
- Plant trees/shrubs
- Water bar
- End haul material
- Fill slope pullback

- Brushlayer
- Clean ditchline
- Seed
- Correct water diversion
- Landing pullback
- Handseed
- Willow wattle
- Aerial seed
- Add larger culvert
- Armoring
- Water diversion.

The sources contributing the most significant amounts of sediments through mass wasting or surface erosion to tributaries of the Skokomish River and the mainstem Skokomish include nine forest roads that deliver sediment to five major creeks. In addition, 15-mass wasting sites caused by 1994-1995 winter storms have been identified. Most of these sites are associated with the forest roads.

Hydrology

The Watershed Analysis stresses the importance of restoring the natural hydrologic balance:

> The balance of subsurface and surface water is disrupted by removal of vegetation in rain-on-snow regions, interception of subsurface water in road ditches, increased runoff with vegetation removal on shallow soils and road surface compaction increasing [decreasing?] runoff response time during storms (USFS 1995).

A specific term is defined within the plan that allows for quantification of the effects of removal of watershed vegetation on watershed hydrology:

> Hydrologic maturity is related to the ability of the vegetative cover to store snow. The greater the canopy crown closure of the forest, the less snow is stored on the hillside and therefore available for runoff during subsequent precipitation runoff events. Hydrologically mature represents forested stands with greater than 70 percent canopy crown closure, intermediate hydrologic maturity represents stands with 10-70 percent canopy crown closure, and hydrologically immature represents stands with less than 10 percent canopy closure. Non-forested vegetative covers are considered to be hydrologically immature because of their ability to store deep snowpacks and generate rapid melt during periods of rain-on-snow conditions (USFS 1995).

The following describes the approach recommended by the plan for hydrologic recovery (italics added):

> Recovery of the hydrologic balance takes time. There is limited science to guide vegetation management. Vegetation age, age distribution, and soil depth are important factors determining hydrologic response. Recovery

strategies should employ retaining existing canopy covers until the basin is responding as a hydrologically mature "unit". A guide is 'Hydrologically mature stands have greater than 70% total crown closure and less [greater?] than 70 percent crown closure of hardwoods or shrubs' (DNR, 1993) . This guide, however, should not be considered as a cookbook. Distribution of stand canopy, soil depth, and amount of hardened surface must be considered as well. *Strategies to consider in hydrologic recovery treatments are delaying thinning, smaller harvest units with longer re-entry periods, and reduction of road as deemed by site level analysis* (USFS 1995).

South Fork Watershed: Analysis Approach

No new analysis was completed for this issue. However, considerable analysis was completed for the Watershed Analysis Sections 3.3, 3.4, and 3.5 form the basis for the recommendations presented below.

South Fork Watershed: Analytical Conclusions

Analytical conclusions are described above.

South Fork Watershed: Recommended Actions

The following is a summary of the recommended actions for lands managed by the USFS and addressed in the Watershed Analysis:

- Create riparian reserves along streams and rivers to the maximum widths recommended in Federal Standards. The function of these reserves is to moderate erosion, release subsurface water more slowly to reduce the effects of runoff, and enhance terrestrial and aquatic habitats
- Continue implementing sediment input reduction actions, with priority given to projects based on potential of site to deliver sediment to streams or sustain vegetative cover.
- Evaluate road management objectives and maintenance strategies to address sediment reduction on high-sediment roads.
- Eliminate unstable sidecast areas and mass-wasting hazards with a high risk of delivery to streams
- Use strategies such as delayed thinning, smaller harvest units with longer periods between harvests, and reduction of road construction to promote hydrologic balance. Retain canopy covers with greater than 70 percent crown closure, while considering other factors such as distribution of stand canopy, soil depth, and amount of hardened surface.
- Continue successful watershed restoration projects such as road decommissioning and bioengineering of eroding slopes.

The following are recommendations for action on Simpson lands, and are based on their communications during development of this CFHMP:

- Simpson should complete a watershed analysis for lands it owns in the Skokomish Watershed, as planned. Historical and current volume estimates of mass erosion rates, sediment delivery to streams, and transport to the mainstem should be provided for use in a mainstem sediment balance. Recommendations resulting from the analysis should equal or exceed those presented in the Watershed Analysis in terms of watershed restoration, especially in the area of sediment control.
- Simpson should make copies of its *Road Maintenance, Rehabilitation, and Abandonment Plan* available to all members of the PAC and Skokomish Valley Residents. Periodic presentations to the PAC and valley residents on the status of implementation of the plan and the Watershed Analysis are recommended.

South Fork Watershed: Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions:

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Promote programs and strategies that are, to the greatest extent possible, consistent with the Tribe's goal of restoring the Skokomish River watershed through its watershed plan (objective).
- Incorporate existing information from other plans to provide direction in completing a plan for the Skokomish Valley, including the Skokomish Tribes Watershed Restoration Plan (when completed), the watershed plan of the Hood Canal Ranger District (when completed), Ecology's 1988 Draft, Skokomish River Comprehensive Flood Hazard Management Plan, and other documents that may prove relevant (objective).
- Address the issue of logging practices and the accumulation of bedload in the Skokomish River, and recommend a process for investigating those practices in an effort to reduce rates of bedload deposition (issue).

Lower Watershed Recommendations

A principal goal of this CFHMP is to restore and maintain the water and sediment carrying capabilities of the Skokomish River system. This will require addressing the root problems of channel aggradation by 1) reducing or eliminating unnatural sediment contributions from South Fork forest lands using methods identified in South Fork Watershed Recommendations, above; and 2) reducing or eliminating the Cushman Project's contribution to the river's reduced sediment carrying capabilities with managed flushing flow releases for the mainstem (see Issue 2, Cushman Project).

Lower Watershed Gravel Removal Recommendations

In addition to direct mitigation measures that address the root causes of increased mainstem channel aggradation, several complementary actions are recommended to mitigate sediment-related flood damages, further quantify sedimentation processes, and investigate innovative approaches to sediment management.

Gravel removal proposals should be coordinated with overall plans for restoring and maintaining channel capacity. However, it is not the intent of the Plan to make gravel removal projects contingent upon prior implementation of managed flows designed to increase the mainstem's sediment transport capabilities.

Gravel Removal: Alternatives

Gravel removal alternatives for the mainstem generally fall into two categories, gravel bar scalping and dredging. Different alternatives may be developed within each of these categories depending on the amount of material removed. Gravel bar scalping differs from dredging in the location from which gravel is removed (see Figure 6-4).

Each of these approaches was analyzed. The gravel bar scalping analysis was completed for this CFHMP using the previously described HEC-2 model. Analysis of the dredging alternative was completed by the COE under a separate project for the Skokomish Tribe. While the analytical approaches differ, both used the HEC-2 model, and the results can be compared in terms of the relative reductions in flood hazards.

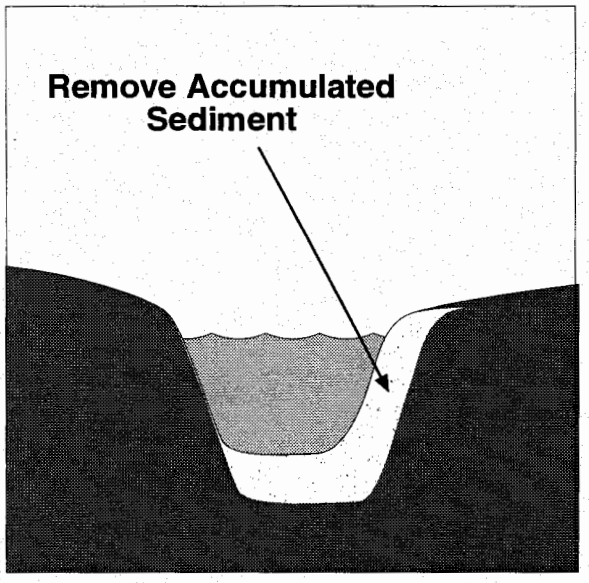
A third option for gravel management is removal of sediment from the river prior to its transport and deposition in the mainstem. Several mechanisms can achieve this, including sediment exclusion and ejection. While this option has been discussed by a variety of Skokomish River stakeholders, its cost and feasibility have not been analyzed. Additional details are provided below.

The analysis approach and analytical conclusions for the dredging and gravel bar scalping alternatives are presented separately. These two alternatives are addressed, together with the sediment exclusion and ejection alternative, in the recommended actions and relevant objective sections.

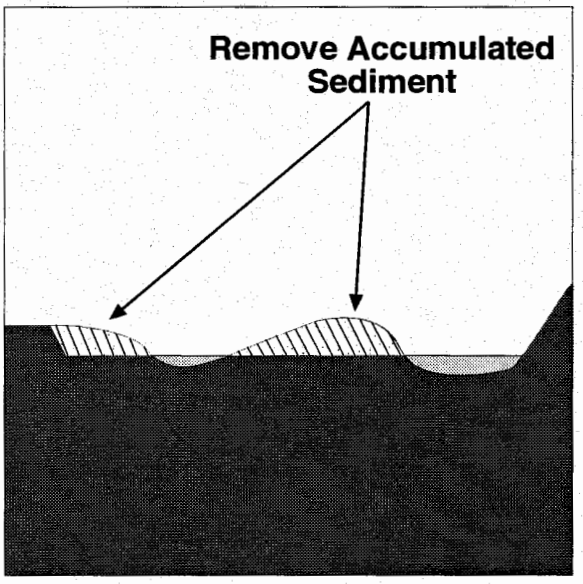
Tribal Position

Throughout the analysis and development of recommendations concerning gravel removal, and throughout the CFHMP as a whole, the concerns of the Skokomish Tribe have been taken into consideration. One of the goals of this CFHMP is to develop flood hazard management strategies that are, to the greatest extent possible, consistent with tribal efforts and tribal values.

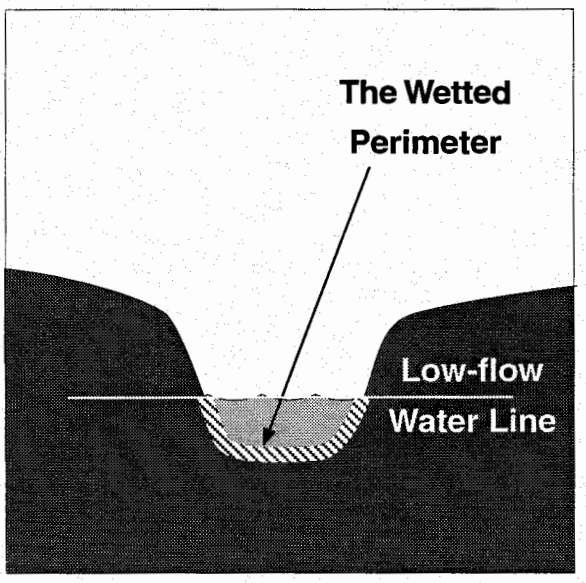
At this time, the Skokomish Tribe's Watershed Restoration Plan has not been completed. For this reason, it is not possible to say whether the details of this CFHMP are completely consistent with the Tribal Plan. However, throughout the drafting of this CFHMP the Tribe has been represented on the CFHMP Planning Advisory Committee, and Tribal communications on several flood hazard management issues have been received. As a result, some of the key objectives of the Tribal Plan have been articulated, and have been taken into account during the drafting of the CFHMP.



Dredging is the removal of accumulated sediments along the bottom and sides of the river channel, to enlarge the channel's capacity for all flows.



Scalping is the removal of gravel and sediment from bars that are normally above the water surface. This increases capacity during high-flow events.



The "**wetted perimeter**" is the portion of the river channel that is usually under water during low-flow conditions.

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-4. DREDGING, GRAVEL BAR SCALPING, AND THE WETTED PERIMETER

The Skokomish Tribe supports dredging the mainstem Skokomish River. Comments on the Updated Scoping Document 2 for the Cushman Hydroelectric Project indicate that

> Mechanical dredging may be - likely will be - required to restore main-stem channel capacity and expedite near-term restoration of near-full or natural flows. The Tribe, National Marine Fisheries Service, U.S. Environmental Protection Agency, and other resource managers disagree with FERC staff that main-stem dredging is not a reasonable alternative.
>
> The Tribe appreciates FERC staff's concern for the potential effects of dredging on anadromous fish. However, mainstem salmon habitat has been so seriously degraded by channel aggradation and dewatering that dredging can only be considered a significant enhancement for salmon, as well as essential to restore channel hydraulic capacity, lower elevated water tables, reduce incidence of overbank flooding (Martino, V., 4 April 1994, personal communication).

The tribe further summarized their view of the gravel management in a letter to the County in early 1995:

> The Tribe and County have documented that persistent deposition of sediment in the mainstem channel has substantially reduced its capacity to carry water, resulting in increasingly more frequent flooding and rising groundwater levels. The river's ability to carry sediment to Hood Canal decreases as the channel fills, further aggravating this problem over time.
>
> Our hydrologists advise that, unless measures are taken to restore the sediment carrying capacity of the river, the channel will continue to fill at an increasing rate, frequency and severity of floods will accelerate, and the river will be forced to cut a new channel
>
> In summary:
>
>> Proposals for mechanical gravel removal are subjected to a high level of scrutiny and are generally held in disfavor as stand alone measures.
>>
>> The Tribe and resource agencies believe that gravel removal may be necessary to restore channel capacity and sediment transport capabilities, in combination with bankfull flushing flows from the Cushman Project.
>>
>> Any necessary gravel removal must be accomplished within the context of a comprehensive plan to reduce flood hazard and to restore natural watershed / ecosystem functions, including channel capacity and sediment transport capabilities.
>>
>> Our best hope to achieve the County's and Tribe's shared objectives is to integrate consideration of any necessary gravel removal with other complementary measures in the context of Skokomish River Flood Hazard Planning, Comprehensive Watershed Planning, and Cushman Project FERC licensing proceedings (Martino, V., 24 January 1995, personal communication).

Gravel Bar Scalping Analysis Approach

An initial gravel removal analysis was completed to determine the amount of material above the low water line of the mainstem and a portion of the South Fork. This analysis was to provide a bounding estimate of the volumes to be removed in the most extensive gravel bar scalping program possible. The river was divided into five reaches for this analysis; the reaches and the results of the analysis are shown in Figure 6-5. The total amount of gravel above the low water elevation was found to be 569,000 cubic yards.

A more detailed gravel bar scalping analysis was completed to determine how much additional flow capacity would be available after gravel bar scalping was completed. If more water could be conveyed in the channel, less water would end up in the floodplain, and a reduction in flood damage would be achieved.

The following steps were completed for this analysis:

- The location of exposed gravel bars was shaded on a set of 1″ = 200′ scale maps showing valley topography in March 1994. Aerial photographs was also used to identify exposed gravel bars
- A set of HEC-2 cross-section plots of existing conditions without the dikes was compiled (see above discussion of the no-dike model)
- Using the topographic maps and air photos, cross-sectional areas representing gravel bars were shaded on the HEC-2 cross section plots to show where gravel bars were removed
- The resulting channel configuration after gravel bar removal was programmed back into the model
- A range of flow rates was run through the HEC-2 models. The five flow rates used were 4,000, 6,000, 10,000, 16,200 (the 2-year flood event), and 21,500 cfs (the 5-year flood event)
- Water surface elevations corresponding to each of the elevations were tabulated. These flow rates were then compared with the highest ground surface elevations of the adjacent overbank areas. The height of water above the higher adjacent overbank area (left or right) was determined. The point at which the water began flowing over the lower adjacent riverbank and the associated discharge were calculated
- The discharge associated with the start of flooding after gravel bar scalping was compared to the channel capacity under the no-dike scenario. The increase in channel capacity was then calculated as the difference in channel capacity before and after gravel bar scalping
- An additional comparison between the no-dike base case and the gravel removal scenario was made to determine the reduction in flood stage during a 5-year flood event. This comparison was completed for Cross-sections 32 through 56.

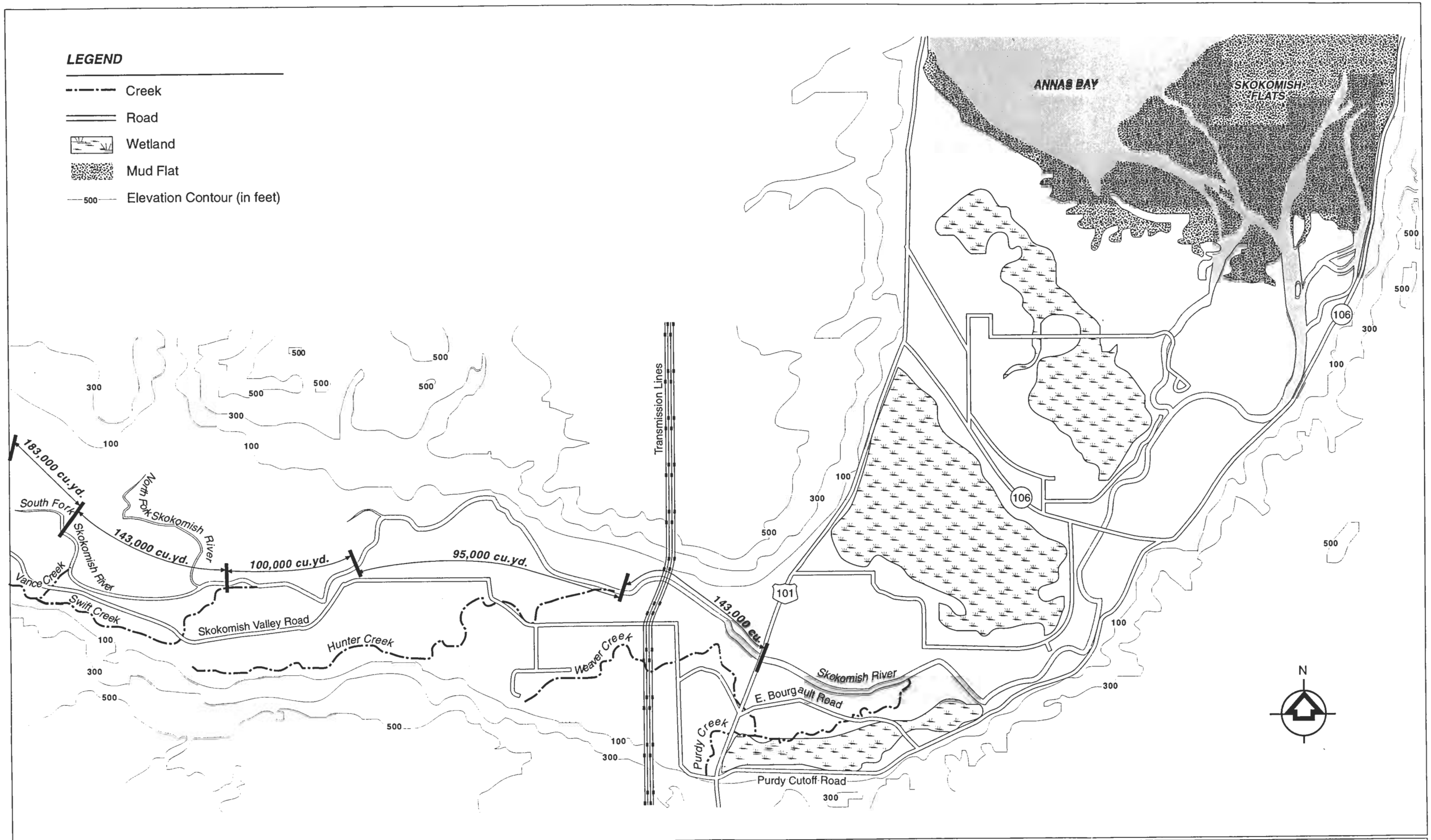


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Figure 6-5.
GRAVEL BAR VOLUMES ABOVE LOW WATER ELEVATION

The locations of gravel removal are shown in the cross-section plots presented in Appendix V and Figures 6-6a through 6-6c. The maps also show the decrease in water surface elevation expected during the 5-year event and the increase in channel capacity. A complete tabulation of water surface elevations and depths above adjacent overbank ground for the five flow rates is presented in Table 6-9. A comparison of channel capacity under the no-dike base case and channel capacity after gravel removal is presented in Table 6-10.

Gravel Bar Scalping Analytical Conclusions

As seen in Figures 6-6a through 6-6c and Table 6-10, the increase in river capacity expected to result from gravel bar scalping varies with location, and ranges from 500 to 7,500 cfs. The average increase in flow capacity is expected to be approximately 2,000 cfs. Reductions in stage from the 5-year flood event also vary with location, and range from 0 to 1.3 feet, averaging 0.6 feet.

Dredging: Analysis Approach

The COE completed an analysis of Skokomish River dredging in February 1995 under an agreement with the Skokomish Indian Tribe (COE 1995). The reconnaissance level analysis was completed to provide data to the tribe for environmental, hydraulic, and cost considerations associated with a hypothetical dredging scenario.

The COE analysis included hydraulics, cost, and environmental considerations. A summary of the hydraulic and cost analysis and conclusions is presented below. The COE discussion of the environmental considerations of dredging is included with the complete report in Appendix W. An additional discussion of fisheries considerations associated with gravel removal was prepared by WDFW and is included below.

Hydraulics: The study reach for the analysis was from the river mouth to the confluence of the North and South Forks, a distance of approximately 8.6 miles. The cross-sectional limits of the dredging were 120 feet in width and 3 to 5 feet in depth. A total of 1,000,000 cubic yards of material was to be removed under the scenario.

A HEC-2 model was developed based on cross-sections from the 1980 FEMA study, and altered to reflect the dredging scenario and computer water surface elevations for different flow rates. Reductions in water surface elevations due to dredging were calculated for different river reaches and different flow rates. The results are presented in Table 6-11.

Costs: The COE costs calculated of dredging 1,000,000 cubic yards of material for five scenarios, differing in where disposal would occur. The five scenarios are as follows:

- Hydraulic or clamshell dredging with disposal in an upland site not in the floodplain
- Hydraulic or clamshell dredging with disposal in an upland site adjacent to the floodplain
- Hydraulic or clamshell dredging with disposal in aquatic lands at the mouth of the river

TABLE 6-9
PREDICTED WATER SURFACE ELEVATIONS AFTER GRAVEL REMOVAL FOR A RANGE OF FLOOD EVENTS

		4,000 cfs		6,000 cfs		10,000 cfs		16,200 cfs		21,500 cfs		
HEC-2 Cross Section Number	Overbank Ground Elevation	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Approximate Channel Capacity
24	24.4	25.89	1.49	26.55	2.15	27.31	2.91	28.32	3.92	28.95	4.55	<4000
25	26.6	26.68	0.08	27.40	0.80	28.25	1.65	29.22	2.62	29.91	3.31	4,000
26	28.1	28.43	0.33	29.48	1.38	30.62	2.52	31.76	3.66	32.59	4.49	<4000
27 - L	33.0	28.59		29.66		31.10		32.62		33.72	0.72	
27 - R	28.0	28.59	0.59	29.66	1.66	31.10	3.10	32.62	4.62	33.72	5.72	<4000
overflow L	33.4					29.11		30.94		31.92		
overflow R	31.2					29.11		30.94		31.92	0.72	
28 - L	30.0	28.76		29.87		31.28	1.28	32.77	2.77	33.86	3.86	
28 - R	28.4	28.76	0.36	29.87	1.47	31.28	2.88	32.77	4.37	33.86	5.46	<4000
overflow L	32.5					30.02		31.93		33.10	0.60	
overflow R	30.5					30.02		31.93	1.43	33.10	2.60	
29 - L	30.5	28.96		30.15		31.58	1.08	33.12	2.62	34.25	3.75	
29 - R	29.0	28.96		30.15	1.15	31.58	2.58	33.12	4.12	34.25	5.25	4,000
overflow L	30.9					30.44		32.33	1.43	33.56	2.66	
overflow R	28.5					30.44	1.94	32.33	3.83	33.56	5.06	
30 - L	29.5	29.20		30.47	0.97	32.98	3.48	33.56	4.06	34.72	5.22	
30 - R	28.0	29.20	1.20	30.47	2.47	31.98	3.98	33.56	5.56	34.72	6.72	<4000
overflow L	32.4					30.82		32.65	0.25	33.87	1.47	
overflow R	32.1					30.82		32.65	0.55	33.87	1.77	
31 - L	30.5	29.52		30.80	0.30	32.31	1.81	33.95	3.45	35.15	4.65	
31 - R	30.3	29.52		30.80	0.50	32.31	2.01	33.95	3.65	35.15	4.85	5,000
overflow L	34.7					31.50		33.29	1.59	34.51	2.81	
overflow R	33.0					31.50		33.29	0.29	34.51	1.51	
32 - L	32.0	29.72		31.02		32.51	0.51	34.17	2.17	35.40	3.40	
32 - R	31.5	29.72		31.02		32.51	1.01	34.17	2.67	35.40	3.90	7,500
overflow L	33.9					32.52		34.18	0.28	35.39	1.49	
overflow R	32.3					32.52	0.22	34.18	1.88	35.39	3.09	
33 - L	33.3	29.81		31.13		32.64		34.30	1.00	35.51	2.21	
33 - R	31.9						0.74		2.40		3.61	8,000
34 - L	35.45	30.18		31.56		33.23		35.08		36.49	1.04	
34 - R	31.83						1.40		3.25		4.66	6,500
35	34.68	30.86		32.30		34.14		36.09	1.41	37.50	2.82	11,500
36	34.87	32.38		33.71		35.90	1.03	38.02	3.15	39.48	4.61	8,000
37	35.34	33.74		34.67		36.61	1.27	38.59	3.25	40.01	4.67	7,500
38	36.88	35.63		36.40		37.80	0.92	39.54	2.66	40.86	3.98	7,500
39	35.89	36.05	0.16	36.87	0.98	38.25	2.36	39.96	4.07	41.24	5.35	<4000
40	37.83	36.55		37.42		38.84	1.01	40.61	2.78	41.97	4.14	7,000
41	40.61	38.63		39.71		41.14	0.53	42.58	1.97	43.68	3.07	8,500
42	43.28	40.64		41.78		43.30	0.02	44.71	1.43	45.67	2.39	10,000
43	44.55	41.75		42.73		44.09		45.51	0.96	46.49	1.94	12,000
44	42.59	43.08	0.49	43.95	1.36	45.27	2.68	46.73	4.14	47.68	5.09	<4000
45	46.58	43.63		44.48		45.79		47.29	0.71	48.23	1.65	13,500
46 - R	47.77	46.13		46.89		47.98	0.21	49.21	1.44	50.05	2.28	9,500
47 - R	49.21	47.24		47.69		48.92		50.06	0.85	50.86	1.65	11,500
48 - R	50.50	47.89		48.57		49.52		50.64	0.14	51.42	0.92	15,500
49 - R	50.84	48.70		49.37		50.34		51.44	0.60	52.21	1.37	13,000
50 - R	53.82	50.04		50.59		51.42		52.38		53.08		>21500
51 - L	53.50	52.25		52.67		53.30		53.98	0.48	54.46	0.96	12,000
51 - R	54.75											>21500
52 - L	54.25	53.70		54.34	0.09	55.23	0.98	56.31	2.06	57.09	2.84	5,500
52 - R	53.61		0.16		0.73		1.62		2.70		3.48	<4000
53 - L	53.5	54.77	1.27	55.39	1.89	56.37	2.87	57.58	4.08	58.45	4.95	<4000
53 - R	54.99				0.40		1.38		2.59		3.46	4,500
54 - L	57.75	56.44		56.97		57.84	0.09	58.92	1.17	59.73	1.98	9,500
54 - R	57.5						0.34		1.42		2.23	8,500
55 - L	61.29	59.21		59.60		60.23		61.00		61.52	0.23	19,000
55 - R	60.76								0.24		0.76	14,500
56 - L	63.8	61.85		62.42		63.35		64.49	0.69	65.33	1.53	12,500
56 - R	61.75		0.10		0.67		1.60		2.74		3.58	<4000
57 - L	68.15	63.60		64.07		65.05		66.15		66.93		
57 - R	66.40										0.53	18,000
58 - L	68.37	64.91		65.19		66.61		67.82		68.65	0.28	
58 - R	66.36						0.25		1.46		2.29	9,000
59 - L	72.35	66.46		67.26		68.52		69.89		70.98		
59 - R	69.94										1.04	16,500
60 - L	73.74	67.72		68.64		70.17		72.11		73.39		
60 - R	74.91											>21500
61 - L	76.18	70.77		71.04		71.66		72.99		74.11		
61 - R	76.27											>21500
62 - L	77.48	42.53		73.20		74.15		75.20		76.04		
62 - R	76.88											>21500
63 - L	78.0	73.88		74.55		75.57		76.70		77.42		
63 - R	78.0											>21500
64 - L	83.78	78.82		78.37		79.75		80.59		80.72		
64 - R	81.92											>21500
65 - L	88.16	82.82		84.19		85.05		85.41		86.39		
65 - R	88.2											>21500
66 - L	92.1	85.20		85.82		87.15		87.85		88.62		
66 - R	89.49											>21500
67 - L	99.76	89.84		90.30		90.98		92.28		93.11		>21500
67 - R	95.74											>21500
68 - L		94.78		95.62		96.92		97.86		98.65		
68 - R	96.27						0.65		1.59		2.38	8,000

General Notes:
The capacity of the flow corridor was analyzed using HEC-2.
Depth above overbank ground column indicates height of water surface elevation above overbank high ground. These data were used to estimate the flow capacity of the corridor.
The analysis assumes that all flow is contained strictly within the defined flow corridor.
16,200 cfs = 2 yr flood event, 21,500 cfs = 5 yr flood event
Notes on Results of analysis for sections 57-68:
No berms were proposed in this reach, but an estimate of the flow capacity of the river was desired. A flow corridor was opened by approximate high points along the left and right overbank.

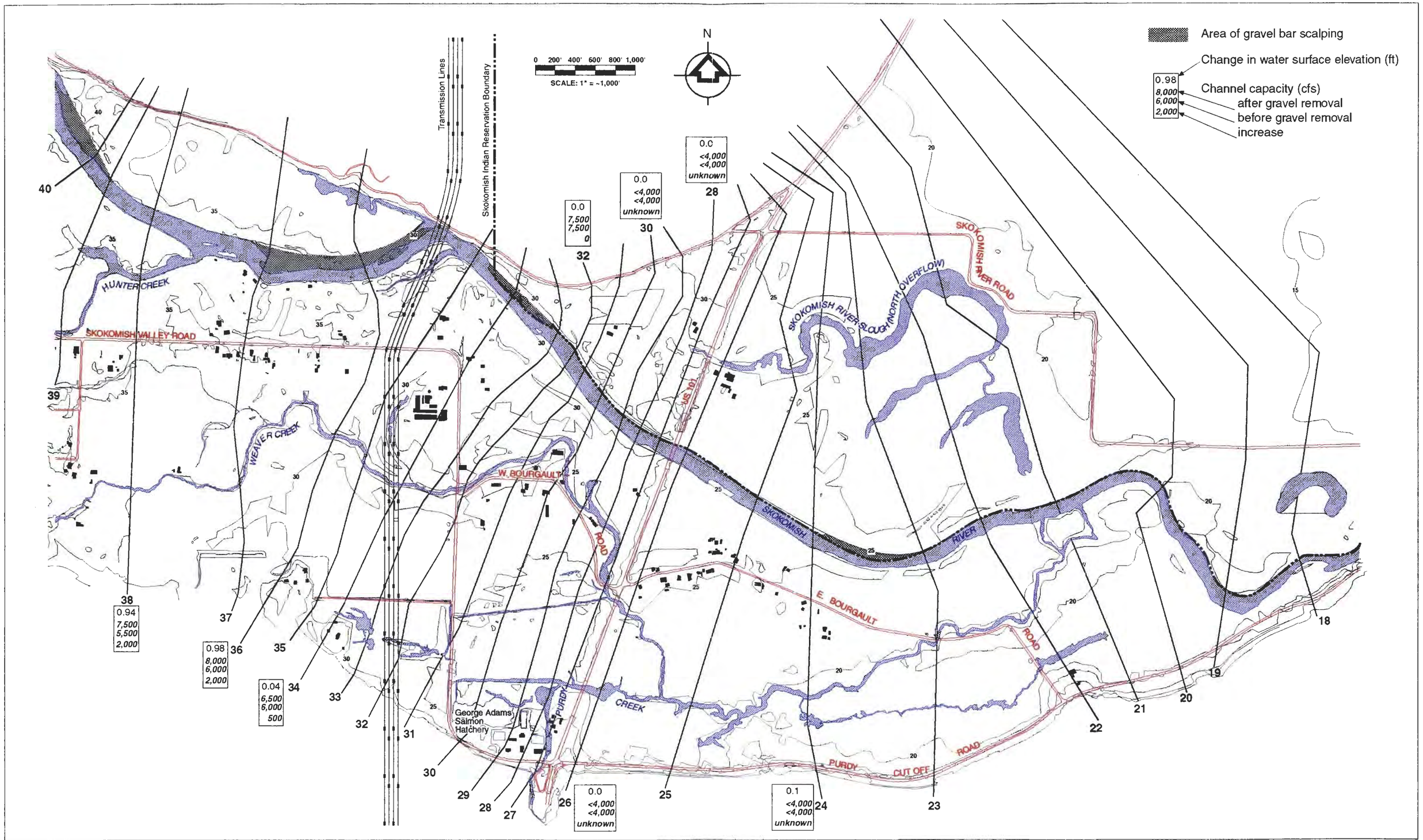

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Figure 6-6a.
GRAVEL BAR SCALPING SCENARIO—
WEAVER/PURDY CREEK VICINITY

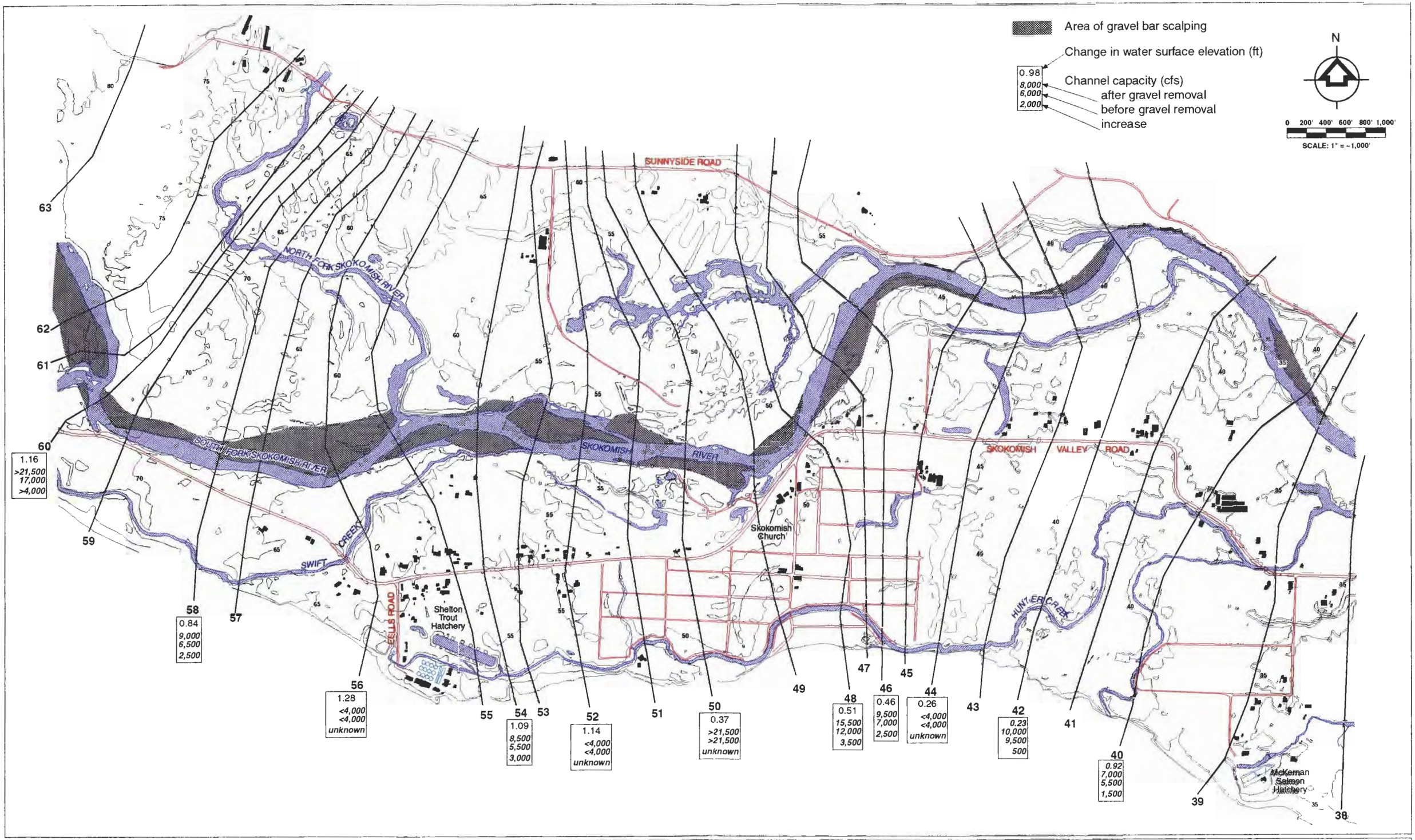

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Figure 6-6b.
GRAVEL BAR SCALPING SCENARIO—
HUNTER CREEK VICINITY

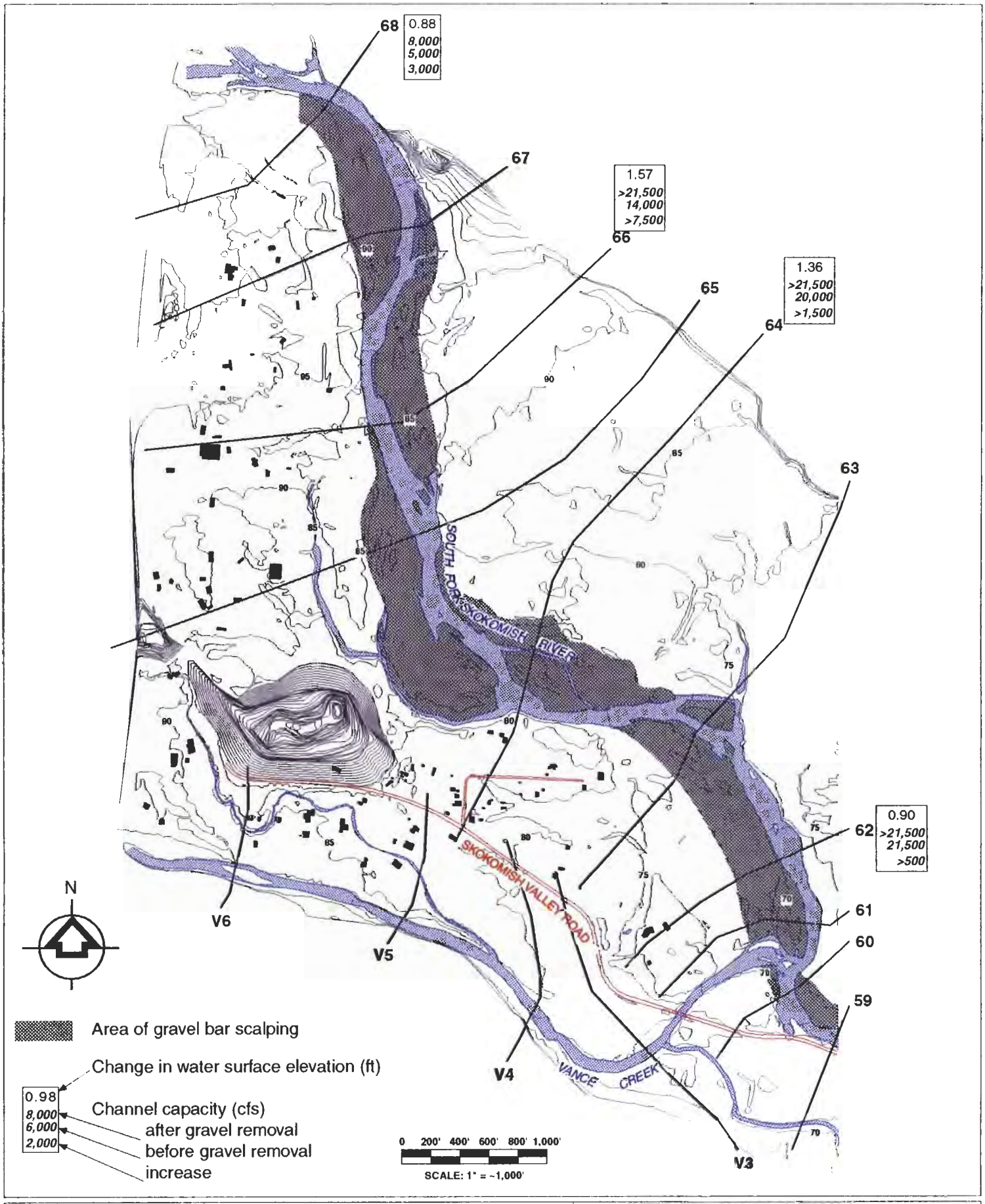

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Figure 6-6c. .
GRAVEL BAR SCALPING SCENARIO
—FIVE MILE CORNER/VANCE CREEK
VICINITY

TABLE 6-10.
COMPARISON OF CHANNEL CAPACITY
BEFORE AND AFTER GRAVEL REMOVAL

HEC-2 Cross Section Number	Approximate Channel Capacity Prior to Gravel Removal	Approximate Channel Capacity Following Gravel Removal	Increase in Channel Capacity from Gravel Removal
28	<4,000	<4,000	unknown
29	4,000	4,000	0
30	<4000	<4000	unknown
31	5,000	5,000	0
32	7,500	7,500	0
33	8,000	8,000	0
34	6,000	6,500	500
35	10,000	11,500	1,500
36	6,000	8,000	2,000
37	5,000	7,500	2,500
38	5,500	7,500	2,000
39	<4,000	<4000	unknown
40	5,500	7,000	1,500
41	6,000	8,500	2,500
42	9,500	10,000	500
43	11,000	12,000	1,000
44	<4,000	<4000	unknown
45	12,000	13,500	1,500
46	7,000	9,500	2,500
47	9,000	11,500	2,500
48	12,000	15,500	3,500
49	10,500	13,000	2,500
50	>21,500	>21,500	unknown
51	20,500	>21,500	>1,000
52	<4,000	<4,000	unknown
53	<4,000	<4,000	unknown
54	5,500	8,500	3,000
55	12,500	14,500	2,000
56	<4,000	<4000	unknown
57	10,500	18,000	7,500
58	6,500	9,000	2,500
59	12,500	16,500	4,000
60	17,000	>21,500	>4,500
61	>21,500	>21,500	unknown
62	21,000	>21,500	>500
63	17,500	>21,500	>4,500
64	20,000	>21,500	>1,500
65	21,500	>21,500	unknown
66	14,000	>21,500	>7,500
67	>21,500	>21,500	unknown
68	5,000	8,000	3,000
Average Increase in Capacity Due to Gravel Removal:			2,000

TABLE 6-11.
POTENTIAL REDUCTION IN WATER SURFACE ELEVATIONS DUE TO HYPOTHETICAL DREDGING SCENARIO

Location	Event	Reduction in Water Surface Elevation (ft)
Just Upstream of SR 106	2-year	1.44
Just Upstream of SR 106	10-year	1.34
Just Upstream of SR 106	100-year	0.77
Just Upstream of SR 101	2-year	1.18
Just Upstream of SR 101	10-year	0.95
Just Upstream of SR 101	100-year	1.01
Average	2-year	0.56
Average	10-year	0.51
Average	100-year	0.35

- Hydraulic or clamshell dredging with disposal at the mouth of the river in Puget Sound
- Hydraulic or clamshell dredging with disposal at the Puget Sound Dredge Disposal Analysis (PSDDA) site off Port Townsend.

Costs: The COE costs calculated of dredging 1,000,000 cubic yards of material for five scenarios, differing in where disposal would occur. The five scenarios are as follows:

- Hydraulic or clamshell dredging with disposal in an upland site not in the floodplain
- Hydraulic or clamshell dredging with disposal in an upland site adjacent to the floodplain
- Hydraulic or clamshell dredging with disposal in aquatic lands at the mouth of the river
- Hydraulic or clamshell dredging with disposal at the mouth of the river in Puget Sound
- Hydraulic or clamshell dredging with disposal at the Puget Sound Dredge Disposal Analysis (PSDDA) site off Port Townsend.

A summary of the costs associated with these scenarios is presented in Table 6-12.

TABLE 6-12
COMPARISON OF HYPOTHETICAL DREDGING AND DISPOSAL OPTIONS PRELIMINARY COSTS (IN 1994 DOLLARS)

Actions/Options	1. Upland off Floodplain Disposal	2. Upland Floodplain Disposal	3. Aquatic Lands Disposal at River Mouth	4. Hood Canal Disposal at River Mouth	5. PSDDA Disposal Site at Port Townsend
MOB	30,000	20,000	30,000	30,000	30,000
Dredge Channel Waste	1,500,000	NA	1,500,000	1,500,000	1,500,000
Hydraulic Dredge and Pump	NA	5,500,000	NA	NA	NA
Setup Fee	NA	NA	NA	2,000	2,000
Dispose Truck Haul	4,800,000	NA	2,400,000	NA	NA
Dispose Barge Haul	NA	NA	NA	1,100,000	3,300,000
Disposal Fee	NA	NA	NA	2,000	2,000
Disposal Sitework	600,000	600,000	600,000	NA	0
Bridge Removal	NA	NA	NA	MISSING	MISSING
Overhead (15%)	1,040,000	828,000	680,000	395,000	792,000
Profit (10%)	693,000	83,000	453,000	263,000	528,000
Contingency (25%)	2,166,000	1,608,000	1,416,000	823,000	1,651,000
CONSTRUCTION COSTS (TOTAL)	**10,829,000**	**8,639,000**	**7,079,000**	**4,113,000**	**8,253,000**
REAL ESTATE	MISSING	MISSING	MISSING	0	0
Engineering & Design (15%)	1,624,000	1,206,000	1,062,000	617,000	1,238,000
Construction Management (10%)	1,083,00	804,000	708,000	411,000	825,000
TOTAL PROJECT COST	**13,536,000**	**10,649,000**	**8,849,000**	**5,143,000**	**10,316,000**

MISSING — Costs not readily available not in the estimate but would still need to be added to the total

SOURCE: U.S. Army Corps of Engineers

Dredging: Analytical Conclusions

Hydraulics: As indicated in Table 6-11, the average expected reduction in water surface elevation is less than 0.6 feet for floods ranging from the 2- to 100-year event. The greatest reductions in water surface elevations is expected just upstream of the SR 106 and US 101 bridges. Reductions in these locations range from 0.77 to 1.44 feet, depending on the size of the event and the location of the excavation.

The calculated reductions in water surface elevations will occur immediately after dredging. Maintenance dredging would be required to maintain the reductions if the current level of sediment transport from upstream sources is not reduced.

Costs: The total cost for the dredging scenarios was estimated at between $5.1 and 13.5 million, depending on the disposal area. The cost per cubic yard is roughly $5 to $13. The COE suggests that additional considerations may alter the cost estimates. For example, the cost of real estate was not included, and would likely increase the costs. Sale of dredged material might decrease project costs; however, the large amount of material that would become available in a short period of time would likely outstrip demand. In addition, as mentioned above, maintenance dredging would be required to maintain reductions in flood levels incurring additional ongoing costs.

Sediment Exclusion and Ejection

Removal of sediment prior its deposition in the mainstem can be accomplished through a variety of methods, categorized as sediment exclusion and sediment ejection (Melone 1975). All the methods included in these categories require construction of instream facilities. Such facilities are costly and require mitigation for environmental impact.

Settling basins are used for removal of both bedload and suspended load. They provide a section wide and long enough that the resulting reduced flow velocity allows the sediment to settle out. Settling basins can be constructed off-line or in-line. Off-line facilities divert water from the river to one or more settling basins, and then route the clear water back to the river. In-line settling basins are widened or deepened sections of a river, in which sediment settles out due to lowered flow velocity. Sediment is then removed from the section by sluicing using water, or through mechanical means such as hydraulic dredges, draglines, and scrapers.

River training works can be constructed to induce channel curvatures that result in controlled deposition of sediment. This approach is based on river hydraulics. When a river flows around a bend, the higher velocity water moves along the outside of the bend while the flow carrying the major portion of the bedload is deflected inwards. By using structural measures to train the river, gravel can be excluded and subsequently removed from the river. Care should be taken to prevent catastrophic re-orientation of the river as a result of the river training.

Vortex tubes are essentially pipes partially buried in the channel bottom. The top of the tube is open and the tube is oriented at an angle to the direction of flow. As water flows over the tube a shearing action across the open portion sets up a vortex motion within and along the tube. This whirling action catches the bedload as it passes over the lip of the opening and carries the sediment to the outlet at the downstream end of the vortex tube, which is located along the side of the channel. Sediment is then removed and the clear water is routed back to the channel.

Other sediment exclusion and ejection alternatives include guide vanes, tunnel excluders, and combinations of the previously describe alternatives. Field data must be collected before developing designs appropriate to local hydraulic and sediment characteristics. A maintenance program must also be developed and implemented to ensure that the facility operates as designed.

The Mason County Department of Public Works has completed an initial identification of nine sites suitable for *gravel sumps*. These sumps would probably function like the in-line settling basins describe above. The locations of these sumps and volumes of material that would be removed during their installation are presented in Figure 6-7. The total volume of material proposed for removal from all nine locations is approximately 150,000 cubic yards.

Gravel Removal: Recommended Actions

Available information indicates that the cumulative effects of activities in the Skokomish River basin have caused sediment deposition in the Valley to occur at greater than natural rates. However, this CFHMP does not support dredging the river at this time, since initial analyses completed by the COE indicate that dredging would, on average, reduce flood levels by only 0.35 feet for the 100-year event.

Several actions are recommended to mitigate sediment-related flood damages, further quantify sedimentation processes, and investigate innovative approaches to sediment management. Implementation of these recommendations, in conjunction with the other structural recommendations, specifically mainstem widening, will reduce flood levels.

Recommended actions related to gravel removal include the following:

- Monitoring
- Gravel bar scalping projects to increase channel capacity
- Feasibility analysis of sediment exclusion and ejection.

Monitoring

The recommended sediment monitoring program consist of two components:

- Monitoring sediment movement at key locations, including locations where historical data is available
- Surveying channel cross-sections annually and taking aerial photos every two to three years to determine how the channel geometry and plan form has changed in response to sediment movement.

Simons and Associates measured suspended sediment, bedload, and discharge for a range of flows at the following locations:

- US 101 bridge
- SR 106 bridge
- One station on the South Fork Skokomish
- Two stations on the North Fork Skokomish.

A monitoring program should be implemented for the same variables for at least the same locations. The program should be designed to collect data both for a uniform time interval and for a range of flow events. The monitoring program should be geared toward collection of sufficient data to produce a mass balance of sediment movement in the watershed.

WDFW requirements for gravel removal programs is to determine the volume of sediment that can be removed without causing an adverse impact on fish. Just as available information is not adequate to quantitatively document long-term changes in riverbed elevations in the Valley, so too are there no long-term records of specific areas of gravel deposition. Two approaches should be taken to remedy this problem and generate a database for sediment deposition in the Valley.

Permanent sections should be established along the river and surveyed at the same time each year. The river sections should be surveyed at the locations used in the 1980 and 1989 surveys. Comparison of surveyed river cross-sections from year to year will document where sediment deposition is occurring and assess whether gravel removal in previous years has had any adverse effect on riverbed stability.

Aerial photographs should be taken and used to generate topographic mapping of the valley every 2-3 years. Gravel bars should be mapped on the topographic maps and compared with topographic mapping from previous years to assess changes in gravel bar volume and location.

Gravel Bar Scalping Projects to Increase Channel Capacity

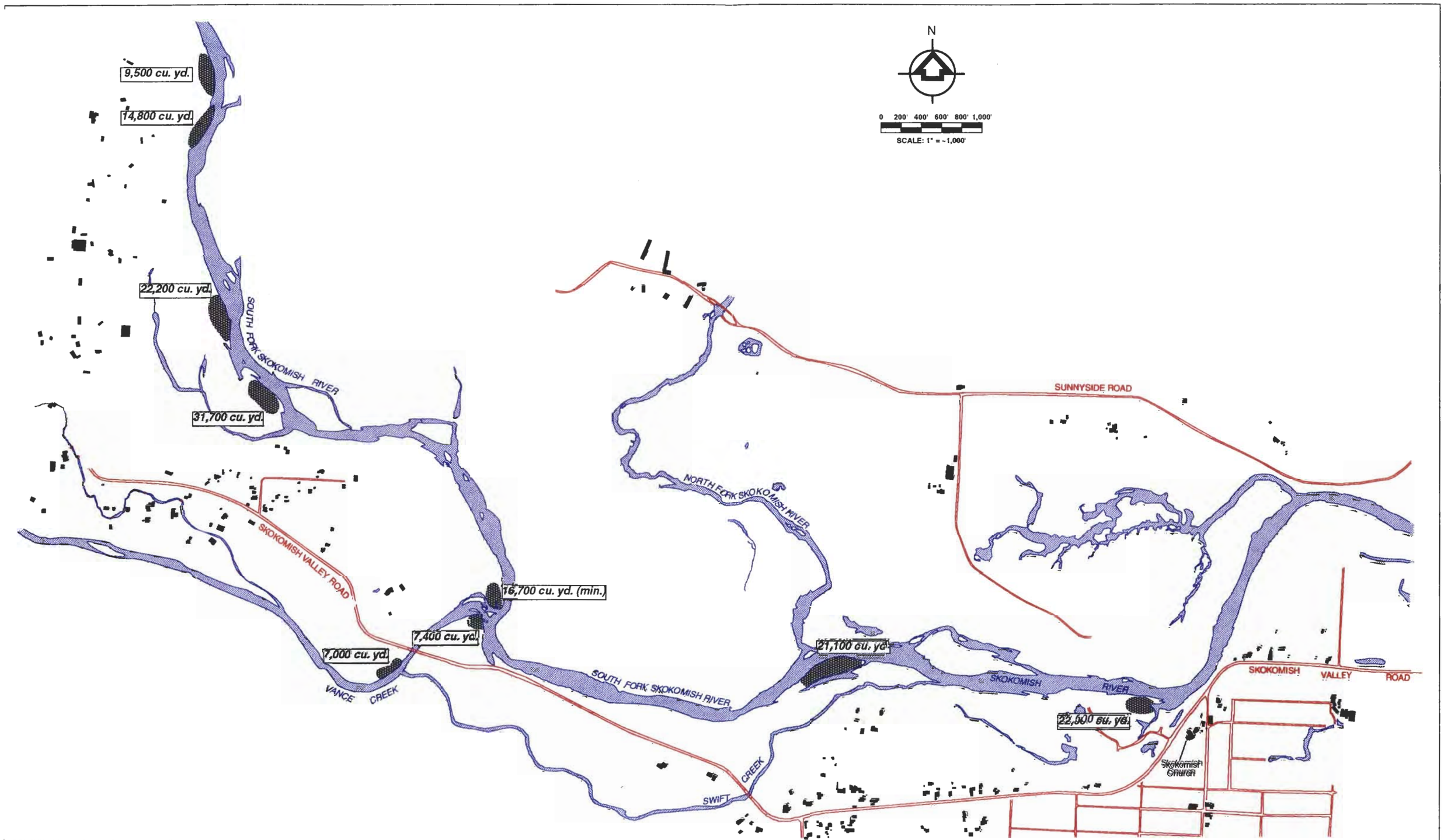
Pre-engineering design analysis is recommended for a program of gravel bar scalping to increase channel capacity in river reaches where insufficient capacity has been documented. This analysis would identify priority locations, estimate expected benefits, costs, and environmental impacts, and identify relationship with overall plans for channel restoration. The following ranked list of cross-sections where adjacent gravel bar scalping should be completed was developed based on the examination of channel capacities upstream and downstream from constricted reaches:

1. Sections 57, 58, 59, and 60
2. Sections 45, 46, 47, 48, and 49
3. Sections 63 and 64
4. Section 66.

Gravel bar scalping is not recommended for locations below Section 43, as actions associated with mainstem widening will increase channel capacity below that section (see below).

Sediment Exclusion and Ejection

The feasibility of sediment exclusion and ejection alternatives should be determined through a detailed feasibility analysis, which was beyond the scope of this plan. The feasibility analysis should include development of conceptual designs for the facility, collection of geotechnical information from potential sites, and completion of a pilot project in which sediment is removed and monitoring is conducted to document localized changes in hydraulics, sediment transport, fisheries, and fish habitat.



SOURCE: Mason County Department of Public Works

KCM 1917 First Avenue Seattle, Washington 98101	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-7. LOCATIONS AND INITIAL REMOVAL VOLUMES FOR PROPOSED GRAVEL SUMPS

Two of the sites proposed by the Mason County Department of Public Works for excavation as settling basins should be selected for pilot projects. Since exclusion and ejection removes sediment before it reaches the flatter valley floor, the sites should be selected from those proposed on the South Fork. Fisheries considerations and access are two criteria that should be used to select the sites (see discussion below).

While the South Fork is the source of the sediments in the mainstem, constructing sediment exclusion and ejection facilities on the South Fork ultimately represents treating the symptoms instead of the problem. In the long run, it will be necessary to modify forest practices and rehabilitate damaged areas within the watershed to adequately protect the South Fork and reduce sediment deposition in the mainstem. As indicated in the recently completed Watershed Analysis for the South Fork Skokomish Watershed, initial steps have been taken to achieve this goal.

Consistency with Tribe

The proposed gravel removal project is consistent with current efforts spearheaded by the Tribe to formulate a watershed plan that includes the possibility of future gravel removal projects in conjunction with the restoration of North Fork flows. The proposed actions in this CFHMP include removal of gravel within the context of a comprehensive plan to reduce flood hazards and to restore natural watershed and ecosystem functions.

Gravel Removal: Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions:

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Promote programs and strategies that are, to the greatest extent possible, consistent with the Tribe's goal of restoring the Skokomish River watershed through its watershed plan (objective).
- Promote and seek funding for gravel removal strategies to improve the hydraulic performance of the River (action).
- Recommend that all flood control options implemented be monitored for results and that these results be documented (action).

Implementation Considerations

There are several considerations that must be addressed prior to initiation of any gravel removal program. They include the effect of upper basin sediment inputs to the mainstem river, the cost of gravel removal, problems associated with access to the river for the removal activities, and the need for and cost of mitigating adverse impact on fisheries and fish habitat.

Upper Basin Sediment Inputs

The effect of sediment inputs on the flood hazard management benefits of a gravel bar scalping program is unclear. Factors that may increase or decrease benefits include the following:

- **The occurrence of extreme flood events:** Larger amounts of sediment are transported during extreme flood events. For example, theoretical calculations for the Nooksack River indicate that approximately 80 percent of the average annual sediment deposited in a local river reach was deposited during the November 8-14, 1990, flood event on that river (KCM 1995).
- **The effect of local channel geometry on hydraulics**: The river alignment, riverbed elevations and slopes, and location of upstream and downstream gravel bars all affect localized sediment transport dynamics.
- **Upper watershed conditions**: Current conditions in the upper watershed will determine how much sediment is available for transport to the lower valley. Natural or human-induced mass erosion events will introduce larger pulses of material to the system.

Average annual sediment transport and deposition volumes have been calculated for the Skokomish and other rivers in Western Washington. While these volumes provide some perspective when compared with removal volumes, they are not cited here because conditions vary from year to year, sediment transport and deposition estimates are typically order-of-magnitude values, and the best way to relate removal volumes to deposition volumes is to conduct a field monitoring program focused on the reach in which removal occurred.

Costs

Costs associated with gravel bar scalping were estimated based on experience in Pierce County and Whatcom County. Pierce County data were provided during a presentation by the Pierce County River Improvement Program to the Planning Advisory Committee on May 18, 1995 (PAC 1995). Whatcom County data come from a report completed for the Lower Nooksack River CFHMP (KCM 1994).

Cost data were available from the Pierce County River Improvement Program for gravel removal in 1987 and 1994. In 1987, the County removed approximately 62,000 cubic yards of gravel at a cost of approximately $132,000 ($2.13 per cubic yard). In 1994, the agency removed approximately 21,000 cubic yards of gravel at a cost of approximately $113,000 (5.38 per cubic yard). Although both numbers reflect costs to the county for removing and disposing of the gravel, the 1994 costs were nearly twice as high due to the disposal location. In 1987, the county disposed of the gravel within the limits of the 100-year floodplain, while in 1994 the County hauled the excavated gravel further away. Pierce County solicited bids for additional gravel removal in 1994. The bids received ranged from $1.25 to $1.35 per cubic yard, which was the price to the contractors. No additional contracts were granted at the time.

Cost data for gravel removal on the Nooksack River were obtained during a meeting with gravel operators in March, 1994. The Lower Nooksack River CFHMP reports that

> The cost to excavate gravel from the bar and transport it to a processing site within 3 miles is estimated to be $2.00 to $2.50 per cubic yard. The cost for transport beyond 3 miles varies with distance. The cost of transport from Everson to Bellingham, for example, a 40 mile round trip, would add an additional $1.50 per cubic yard to the base price. Additional processing of material including screening and washing would add $2 per cubic yard to the base price.
>
> Prices paid by buyers of river gravel depend on how the gravel is processed. Raw pit run gravel is typically sold for $5.00 to $6.00 per cubic yard delivered. If the material is screened and washed, the price increases to approximately $9.00 to $10.00 per cubic yard. Whatcom County recently contracted for crushing and stockpiling of 62,000 cubic yards of 3/8 to 5/8 -inch seal rock, with transport to County pits, for $12.62 per cubic yard (KCM 1994).

Access

Problems of access may add costs to a gravel removal project. The Lower Nooksack CFHMP states that

> Access concerns focus on the three legs of the route along which gravel is moved—from a bar to the shore, from the shore to a County road; and from a County road to the site of end use. Access to the bar from the shore is by way of temporary routes built along the shoreward portion of the bar. Where allowed by permit, temporary bridges are used to cross low water channels. These routes are washed away with seasonal high water and therefore frequent re-establishment is required.
>
> Gravel can be transported from the shore to a County road across private or operator-owned property. Charges based on the amount of material transported are often assessed for private property crossings. Access costs have ranged from 10 to 15 cents per cubic yard in the past. Access to bars along multiple reaches of river generally requires multiple routes, resulting in increased costs. The largest gravel operator on the river (Cowden Gravel and Ready Mix) has purchased property specifically to reduce access costs and be able to maintain paved-road access to the shore.
>
> Truck transport along County roads is necessary to deliver material to the end use site or to processing sites that are far from the excavated bars. County shoreline regulations contain specific requirements relating to entry onto County Roads. Bonding for potential damage to roads may be required (KCM 1994).

Mitigation for Negative Impact on Fisheries and Fish Habitat

(The following was prepared by the WDFW representative on the PAC for the 1993 Draft CFHMP and is reproduced verbatim.)

1. **Relationship of gravel removal from a channel to natural geomorphic processes and fish habitat**

Removal of gravel within a stream channel influences the composition of the bed and the geometry of the channel, and therefore the fish habitat. The existence and character of aquatic life (fish and fish food) are dependent on the local geohydraulic environment to which they have adapted. Any change in the geohydraulic environment will change the fish habitat and the success and distribution of the local salmonid fish accordingly. General river channel impacts that WDF is concerned about relative to gravel removal include the following:

- The effect of gravel bar harvesting on nearby spawning riffles due to change in gradient, water velocity and depth, and gravel composition
- The long-term effect of diminished gravel supplies to downstream spawning reaches
- The effect of realignment of flood flows in the area of harvested bars
- Change in pool and side channel rearing habitats
- Stranding of fish during fluctuating flows in depressions left on gravel bars where harvesting has occurred
- Loss off gravel bars of large woody debris, which contributes to in-stream fish cover

Salmonids require specific habitat types for each stage of life. For example, salmonid spawning requirements include the following:

- A relatively narrow range of depths and velocities over the spawning nests (redds)
- A narrow range of gravel sizes, good gravel abundance, and low gravel compaction
- Adequate water quality, quantity, and intragravel flow
- Stability of gravel to the depth of spawning

The volume, configuration, stability, and cover in in-channel and side-channel pool-rearing habitats are critical to salmonid rearing and production levels.

Except for stream flow, water quality, and bank vegetation, all physical fish habitat is created by natural geomorphic processes. The processes critical to fish habitat are the supply of bedload material from stream banks, streambeds, and bars, and the formation of channel bed forms by deposition and sorting of bedload materials by grain size. The channel characteristics formed by these processes are a result of each stream perpetually seeking an equilibrium of continuous uniform energy expenditure along its length. Meandering, braiding, and bank erosion are energy expenditure processes that create important fish habitat features, such as rearing pools formed at

the outside of gravel bars and gravel spawning areas formed by concentrated gravel deposits in riffles as a result of bedload sorting.

Local modifications to a river, such as gravel removal, can induce short-term and long-term responses. As a result of gravel bar excavation, channel morphology and sedimentation characteristics may be changed; the river will tend to readjust to the geometry and pattern that it had before gravel removal. If the magnitude of the modification is large enough, the readjustment may take decades to complete. The short-term responses are usually observable and may be measurable. Long-term response, however, may be so gradual that the changes will not be noticeable for decades. When a stream is altered locally, the change often causes modification of the channel characteristics for considerable distances upstream and downstream. The change may be quite complex, but all rivers are governed by the same basic forces.

The short-term and long-term responses of a river as a result of gravel removal can adversely affect fish life and habitat, especially if a stream is in relative equilibrium with respect to bedload movement and distribution. Alternatively, if a river is noticeably aggrading and relatively unstable (annual channel shifts, braiding, etc.), contains a high percent of gravel with resultant loss of surface flow to subsurface flow, and lacks stable stream bank vegetation because of channel shifting, there may be some positive aspects to a carefully planned gravel removal program.

2. WDF Management Considerations and Mitigation

WDF currently reviews and approves gravel harvesting from river bars with six general requirements:

- In-stream wet harvesting is not allowed unless justified by flood control needs and if reasonable protection can be made for fish resources
- Gravel bars are required to be sloped toward the water to prevent fish being stranded during fluctuations in water level
- A buffer shall exist between the water margin and work activity
- Work is restricted to the summer flow-flow period after downstream juvenile migration is completed and prior to upstream migration of adults
- The volume rate of removal shall not create geohydraulic changes in the channel that will adversely affect fish life and habitat
- Gravel shall not be stockpiled within the channel.

The concern regarding excess gravel requires that regulatory agencies consider harvestable volume in resource management plans. For some

aggrading streams, gravel may be available for harvest without causing impacts to habitat. For others, retaining stream gravel may be critical for maintaining geomorphic and fish habitat characteristics. At a minimum, stream reaches should be rated and categorized by qualified geohydrologists and fish habitat managers based on existing and obtained data, as to their geohydraulic and biological character in relation to gravel harvest. Necessary base data, including reporting of accurate amounts of gravel harvested, should be required from gravel harvesters. A means of tracking projects, obtaining additional necessary data, and setting gravel rates should be established.

Acceptable gravel harvest rates need to have a basis. Studies done by qualified geohydrologists on the Humptulips, Wynoochee, and Satsop Rivers showed that excessive gravel harvest had historically occurred. Their findings helped to establish a safe gravel harvest rate that is used in Grays Harbor County.

3. Skokomish River Considerations

At present, a Hydraulic Project Approval (HPA) may be written for gravel removal from a river bar with mitigation noted above. Most recent approved projects have been relatively small, a few hundred yards of gravel removed, and very few have applied. All proposed projects are also required to comply with Mason County Shoreline permit regulations. Approval for a much larger gravel removal project for flood control will have to be based on a better understanding of a safe harvestable rate of gravel that will not create geohydraulic changes in the channel that would adversely affect fish life and habitat.

Since development of a safe, acceptable gravel removal rate is not an exact science, a careful plan should include staggered work by area(s) and time, with monitoring the effects of the work on the river geometry, hydrology, and bedload composition.

A relatively new concern includes a possible degradation and observed change in substrate composition in the estuary. The relationship and cause of observed aggradation in substrate upstream and this observed estuary degradation needs to be evaluated in relation to aquatic life and habitat effects. If a relationship exists, additional mitigation (such as transporting gravel to the estuary) may be necessary.

Side Channel Clearing / Mainstem Widening

The northernmost bridge in the valley along US 101 crosses an old, abandoned side-channel sometimes referred to as the Skokomish River Slough. The side-channel originates just upstream of US 101 and re-enters the main channel about 4,200 feet downstream of the bridge. The meandering side-channel is approximately 1.5 miles long. A gravel bar on the main channel currently cuts this side channel off at its entrance and, except during extremely large flood events, the side-channel does not carry any river flow. There are blockages to flow in a few locations, but much of the side channel remains open and collects local drainage from the

hillside to the north. Reopening this channel to flow was proposed in the 1993 CFHMP to decrease flooding on the mainstem and provide additional fish habitat.

Several areas upstream of the bridge are overgrown with brush, and flow is restricted during flood events. Removal of overbank vegetation in the area was recommended in the 1993 draft CFHMP to increase the hydraulic performance of the overflow once it is re-established. However, clearing of growth along this section of the river may adversely affect riparian habitat and the fisheries resource. The loss of shade for fish habitat at this location can be partially offset by the new habitat created in the re-established side-channel.

Following the identification of the alternatives described above, a more detailed scenario was developed for analysis. The alternatives were analyzed with the gravel bar scalping alternative to determine how the combination would affect water levels.

Analysis Approach

The HEC-2 model used in the gravel removal analysis was altered to simulate the hydraulic effect of side-channel clearing and mainstem widening. It was assumed that floodwaters were conveyed only through the mainstem bridge and overflow channel north of the bridge. The following is a description of the specific actions included in the alternative and the changes that were made to the model in order to simulate the actions:

- Selective clearing of trees and brush in the North Overflow from the US 101 bridge to a distance approximately 1,500 feet upstream; Manning's roughness coefficient was reduced to promote more flow in this area. These changes were made to HEC-2 Cross-Sections 27 through 33
- Widening of the mainstem channel of the river; the width of the mainstem of the river was doubled and Manning's roughness coefficient in the widened portion of the channel was reduced. These changes were made to HEC-2 Cross-Sections 27 through 33
- Removal of a forested gravel bar on the north side of the channel; half the gravel bar, above the low water elevation, was removed. Manning's roughness coefficient in the widened portion of the channel was reduced. These changes were made to HEC-2 Cross Sections 36 through 40
- Widening of the downstream end of a meander bend to increase the hydraulic performance of the reach; the south bank of the river was widened by 100 feet. Manning's roughness coefficient for the widened portion of the channel was reduced. These changes were made to HEC-2 Cross-Section 41.

These changes are shown in the cross-sections contained in Appendix X and in Figure 6-8.

Implementation of recommended actions relating to mainstem widening and side channel restoration will require the collaboration with the Skokomish Tribe, and integration with overall planning for channel restoration and improvement of natural sediment transport through managed restoration of flows. In addition, as is the case with any of the actions that may use, divert, obstruct, or change the natural flow or bed of the river, the Washington State Department of Fish and Wildlife (WDFW) would be consulted prior to design and construction.

Analytical Conclusions

Predicted water surface elevations after gravel removal, side-channel clearing, and mainstem widening are presented in Table 6-13. A comparison of the conveyance capacity of the mainstem channel before and after gravel removal, mainstem widening, and side-channel clearing is presented in Table 6-14. Anticipated decreases in water surface elevations during a 5-year event and the expected increase in channel capacity are shown in Figure 6-8.

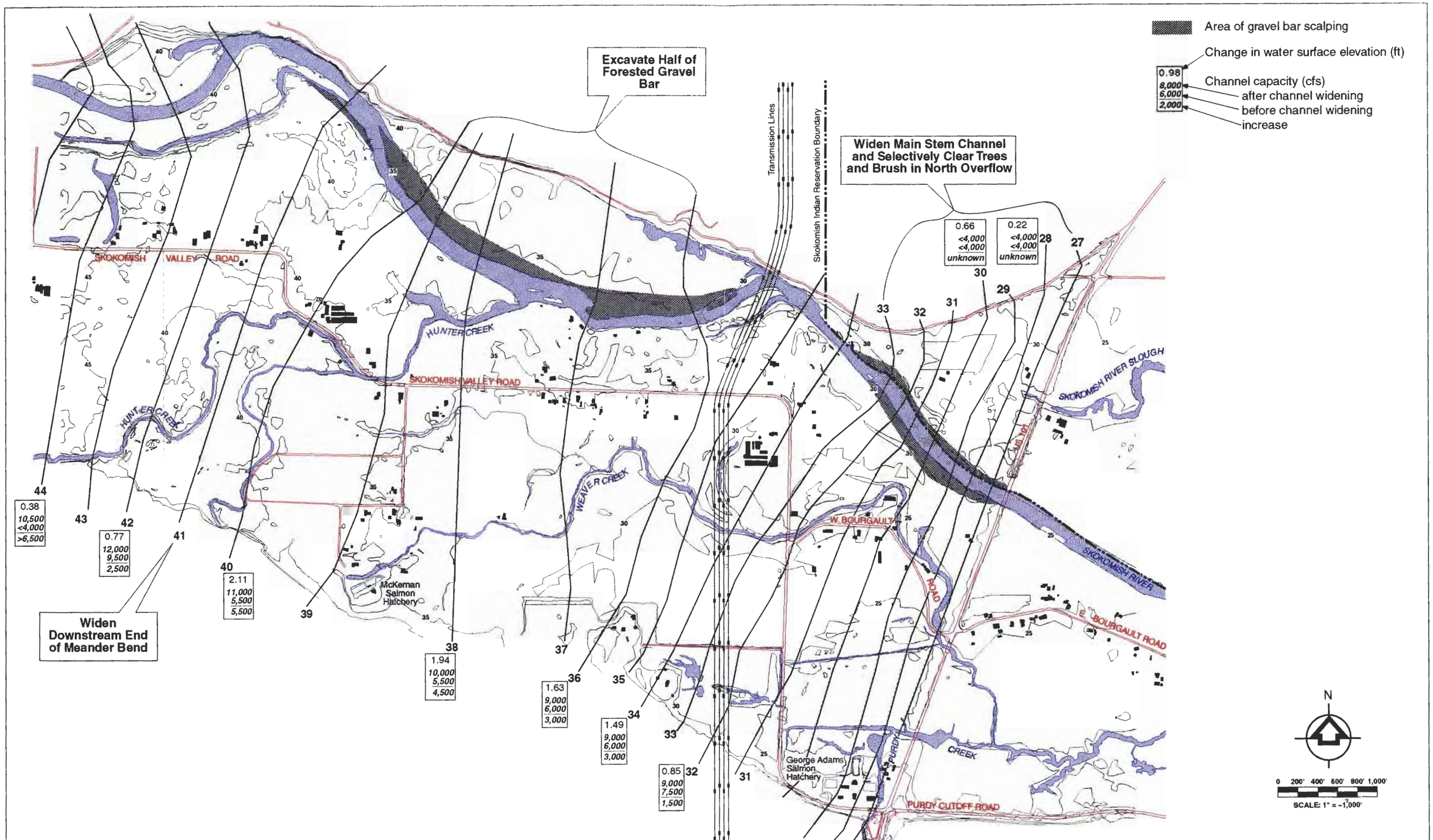
TABLE 6-13.
PREDICTED WATER SURFACE ELEVATIONS AFTER GRAVEL REMOVAL, SIDE-CHANNEL CLEARING AND MAINSTEM WIDENING FOR A RANGE OF FLOOD EVENTS

		4,000 cfs		6,000 cfs		10,000 cfs		16,200 cfs		21,500 cfs		
HEC-2 Cross Section Number	Overbank Ground Elevation	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Water Surface Elevation	Depth Above Overbank Ground	Approximate Channel Capacity
24	24.4	25.89	1.49	26.55	2.15	27.28	2.88	28.29	3.89	28.90	4.50	
25	26.6	26.68	0.08	27.40	0.80	28.19	1.59	29.15	2.55	29.78	3.18	
26	28.1	28.43	0.33	29.48	1.38	30.54	2.44	31.65	3.55	32.39	4.29	
27 - L	33.0	28.70		29.84		31.12		32.55		33.53	0.53	
27 - R	28.0	28.70	0.70	29.84	1.84	31.12	3.12	32.55	4.55	33.53	5.53	
overflow L	33.4					29.47		31.14		31.90		
overflow R	31.2					29.47		31.15		31.90	0.70	
28 - L	30.0	28.79		29.94		31.22	1.22	32.65	2.65	33.63	3.63	
28 - R	28.4	28.79	0.39	29.94	1.54	31.22	2.82	32.65	4.25	33.63	5.23	< 4,000
overflow L	32.5					29.78		31.55		32.47		
overflow R	30.5					29.78		31.55	1.05	32.47	1.97	
29 - L	30.5	28.92		30.09		31.41	0.91	32.89	2.39	33.91	3.41	
29 - R	29.0	28.92		30.09	1.09	31.41	2.41	32.89	3.89	33.91	4.91	4,000
overflow L	30.9					30.21		32.04	1.14	33.10	2.20	
overflow R	28.5					30.21	1.71	32.04	3.54	33.10	4.60	
30 - L	29.5	29.03		30.21	0.71	31.54	2.04	33.04	3.54	34.06	4.56	
30 - R	28.0	29.03	1.03	30.21	2.21	31.54	3.54	33.04	5.04	34.06	6.06	< 4,000
overflow L	32.4					30.52		32.30		33.37	0.97	
overflow R	32.1					30.52		32.30	0.20	33.37	1.27	
31 - L	30.5	29.23		30.41		31.76	1.26	33.29	2.79	34.34	3.84	
31 - R	30.3	29.23		30.41	0.11	31.76	1.46	33.29	2.99	34.34	4.04	6,000
overflow L	34.7					31.18		32.91		33.99		
overflow R	33.0					31.18		32.91		33.99	0.99	
32 - L	32.0	29.38		30.57		31.92		33.48	1.48	34.55	2.55	
32 - R	31.5	29.38		30.57		31.92	0.42	33.48	1.98	34.55	3.05	9,000
overflow L	33.9					31.91		33.48		34.55	0.65	
overflow R	32.3					31.91		33.48	1.18	34.55	2.25	
33 - L	33.3	29.47		30.67		32.04		33.57	0.27	34.61	1.31	
33 - R	31.9											9,500
34 - L	35.45	29.63		30.84		32.26		33.87		35.04		
34 - R	31.83											9,000
35	34.68	30.54		31.85		33.59		35.47	0.79	36.67	1.99	13,500
36	34.87	32.16		33.33		35.35	0.48	37.45	2.58	38.83	3.96	9,000
37	35.34	33.48		34.21		35.96	0.62	37.90	2.56	39.25	3.91	8,500
38	36.88	34.92		35.56		36.86		38.59	1.71	39.86	2.98	10,000
39	35.89	35.22		35.87		37.11	1.22	38.78	2.89	40.02	4.13	6,000
40	37.83	35.83		36.46		37.61		39.18	1.35	40.38	2.55	11,000
41	40.61	38.09		38.90		40.10		41.35	0.74	42.14	1.53	12,500
42	43.28	40.33		41.31		42.76		44.21	0.93	45.13	1.85	12,000
43	44.55	41.71		42.59		43.87		45.26	0.71	46.20	1.65	13,000
44	42.59	43.07	0.48	43.91	1.32	45.20	2.61	46.64	4.05	47.56	4.97	10,500
45	46.58	43.63		44.46		45.74		47.23	0.65	48.14	1.56	13,500

General Notes:

The capacity of the flow corridor was analyzed using HEC-2.
Depth above overbank ground column indicates height of water surface elevation above overbank high ground.
These data were used to estimate the flow capacity of the corridor.
The analysis assumes that all flow is contained strictly within the defined flow
16,200 cfs = 2 yr flood event, 21,500 cfs = 5 yr flood event

The effect of the side-channel clearing, through Section #41, on the completed water surface elevations extended only up to Section #45.
Upstream of this point, the computed water surface elevations were identical to those computed for the gravel removal scenario.



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HAZARD MANAGEMENT PLAN

Figure 6-8.
SIDE CHANNEL CLEARING/MAIN STEM WIDENING ALTERNATIVE—
HUNTER CREEK VICINITY

TABLE 6-14.
COMPARISON OF CHANNEL CAPACITY BEFORE AND AFTER
GRAVEL REMOVAL, MAINSTEM WIDENING, AND SIDE-CHANNEL CLEARING

HEC-2 Cross Section Number	Approximate Channel Capacity Prior to Gravel Removal, Mainstem Widening and Side Channel Clearing	Approximate Channel Capacity Following Gravel Removal, Mainstem Widening, and Side Channel Clearing	Increase in Channel Capacity from Gravel Removal, Mainstem Widening and Side Channel Clearing
28	<4,000	<4,000	unknown
29	4,000	4,000	0
30	<4000	<4000	unknown
31	5,000	6,000	1,000
32	7,500	9,000	1,500
33	8,000	9,500	1,500
34	6,000	9,000	3,000
35	10,000	13,500	3,500
36	6,000	9,000	3,000
37	5,000	8,500	3,500
38	5,500	10,000	4,500
39	<4,000	6,000	>2,000
40	5,500	11,000	5,500
41	6,000	12,500	6,500
42	9,500	12,000	2,500
43	11,000	13,000	2,000
44	<4,000	10,500	>6,500
45	12,000	13,500	1,500
46	7,000	9,500	2,500
47	9,000	11,500	2,500
48	12,000	15,500	3,500
49	10,500	13,000	2,500
50	>21,500	>21,500	unknown
51	20,500	>21,500	>1,000
52	<4,000	<4,000	unknown
53	<4,000	<4,000	unknown
54	5,500	8,500	3,000
55	12,500	14,500	2,000
56	<4,000	<4000	unknown
57	10,500	18,000	7,500
58	6,500	9,000	2,500
59	12,500	16,500	4,000
60	17,000	>21,500	>4,500
61	>21,500	>21,500	unknown
62	21,000	>21,500	>500
63	17,500	>21,500	>4,500
64	20,000	>21,500	>1,500
65	21,500	>21,500	unknown
66	14,000	>21,500	>7,500
67	>21,500	>21,500	unknown
68	5,000	8,000	3,000

Side-channel clearing and mainstem widening increases river conveyance capacity in the vicinity of US 101. The effects extend up to Cross-Section 45, approximately 2 miles upstream of US 101. The average increase in capacity expected to result from mainstem widening and channel clearing through the reach between Sections 31 and 45 is approximately 3,500 cfs. The increase in channel capacity near US 101, when coupled with increases in conveyance capacity upstream as a result of the gravel bar scalping recommended above, will reduce flood stages and associated damages.

Recommended Action

The analysis demonstrates that widening of the mainstem channel, clearing of the overflow, and selective gravel removal in the vicinity of the US 101 bridge can reduce flood levels and increase river capacity. This will reduce flood damage. Therefore, these actions should be implemented in their entirety and in conjunction with the recommended gravel bar scalping actions.

In addition to agency approvals, this project requires the cooperation of the Skokomish Tribe, whose land borders the abandoned side-channel, and residents who live along the channel. Detailed engineering and environmental investigations are necessary to assess the feasibility of this proposal. For example, the entrance to the side-channel would need a control structure to limit the amount of flow entering the channel during a flood. Hydraulic modeling should be conducted to assess flow patterns, velocities, and distribution through this section of the side and main channels. In addition, the physical characteristics of the reopened channel must enhance the fisheries resource of the Skokomish River.

Side-Channel Clearing / Mainstem Widening: Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Promote programs and strategies that are, to the greatest extent possible, consistent with the Tribe's goal of restoring the Skokomish River watershed through its watershed plan (objective).
- Promote and seek funding for gravel removal strategies to improve the hydraulic performance of the River (action).

River Bank Stabilization

River processes are dynamic and lead to changes in flow paths and areas of bank erosion. The most reasonable and cost-effective approach to river management is to provide a river corridor that allows for river adjustments from year to year. Efforts on other rivers to completely control the river and associated bank erosion have been largely unsuccessful and very costly. In much of the Skokomish River through the Valley, minor shifts in river patterns do not cause erosion of productive farm land or create a flood hazard.

Even with the goal of preserving a river corridor, there remain locations along the river where bank erosion is causing a loss of private property and productive land. River bank stabilization is used to mitigate the effects of erosion caused by flood flows, resulting in loss of private property and public facilities. Methods and materials used for bank stabilization are summarized in Appendix S.

One of the most common methods of bank stabilization is the placement of rock riprap on riverbank slopes. However, of all available methods, riprap is probably the least beneficial to riparian and fish habitat. Therefore, more environmentally beneficial bank protection measures, commonly categorized as bioengineering, are generally recommended as the first consideration for bank stabilization efforts. Riprap should be used only where high-velocity flood flows occur and where significant bank erosion creates a serious flood hazard.

Emplacement of rock riprap is recommended in locations where no other solution is feasible and the potential for flood damage is great. Completion of a pre-engineering design for bank protection using rock riprap or bioengineering techniques—including rough drawings, estimate cost, description of expected benefits, identification of environmental effects, and fit with overall flood plan policies and plans—is recommended in the following locations (shown in Figure 6-9):

- Five Mile Corner: The alignment of the river in this area directs the force of the river at the southern bank. Four homes located within 200 feet of the southern bank are threatened by movement of the river during a channel avulsion.
- The Dips: The Skokomish Valley road is located parallel to the river at a distance of 50 feet and less in this area. Water flows over the road in this location during flood events, and is conveyed through the floodplain toward Swift Creek, Eels Road, and the Shelton Trout Hatchery.
- Skokomish Community Church: The dike in the County road right of way at the sharp bend in the river near the church was not built according to current engineering standards and is in danger of failing. An avulsion at this location could damage or destroy the church, several homes and private property, and the Skokomish Valley Road. Stabilization of the river bank at this location will be planned in conjunction with evaluation of the existing dike in the County road right of way consistent with adopted diking policy.

Properly constructed bank protection projects at these locations can reduce the potential for the river to change course. Therefore, bank stabilization can be used instead of or in addition to construction of dikes in areas where there is a potential for avulsion. Installation of bank protection is not a guarantee that an avulsion will not take place, at the project location or elsewhere. In addition, bank hardening will not prevent overbank flows and creation of new channels some distance from the main channel. Rivers such as the Skokomish are dynamic systems in which changes in alignment are to be expected.

Materials and Techniques

The following is a discussion of the standard materials and techniques used in planning and implementing a bank protection project using rock riprap. Similar material for other bank protection approaches is presented in the summary sheets in Appendix S. This discussion is based largely based on *Guidelines for Bank Stabilization Projects in the Riverine Environments of King County* (Johnson and Stypula 1993).

Gradation refers to the size characteristics of the material as it is emplaced. To minimize the chances for structural failure, the material should consist of a variety of rock sizes that are

capable of interlocking and minimizing structural voids. Standards for riprap gradation are available from WSDOT and other agencies.

Filter layers are used as the initial covering over the bank to prevent slumping and failure. Filter layers generally consist of gravel or quarry spalls. Artificial filter fabric may also be used as a filter layer. These materials act to prevent the loss of finer particles which make up the bank and provide stability. Riprap is carefully placed over the filter layer to ensure that it is not ruptured.

Bank slope is a key consideration in structural stability. As a general rule, rock riprap should not be placed on slopes steeper than 2H:1V. Grading of the bank slope may be required prior to emplacement of rock in areas where there are greater slopes.

Rock shape is important since the interlocking nature of the structure provides stability against erosive force. Angular, nearly rectangular rock is preferred, since rock with these characteristics fits together to form a continuous and solid blanket.

A *toe key* is a layer of rock emplaced below the river bed to provide protection against undercutting of the protected bank. Scour analyses should be completed to determine the required depth for emplacement of toe key rock. Typical depths for rock toes are 3 to 5 feet below the lowest bed elevation. The width of the toe key is typically 1.5 to 2 times the thickness of the riprap blanket at the base of the slope. Toe rock must be large enough to remain stable under the flow depths and velocities to which it will be exposed. Toe rock should also be angular shaped to allow for interlocking.

The *height of the riprap face* should be sufficient to provide protection against scour by debris and other floating material, flowing water, and wave action. The height is typically determined by using a safety factor related to the design water surface elevation. Riprap should be placed on the top of the bank where the channel capacity may be exceeded and floodwaters are expected to flow over the bank.

Vegetation growing through the bank structure can provide additional stability. Historically, vegetation was removed from riprapped banks in order to improve access and visibility for maintenance inspections. However, the additional stability provided by vegetation and the concurrent habitat improvement benefits are incentives to retaining vegetation on riprapped banks.

Analysis approach

No analysis was completed for the alternatives.

Analytical conclusions

No analysis was completed for the alternatives.

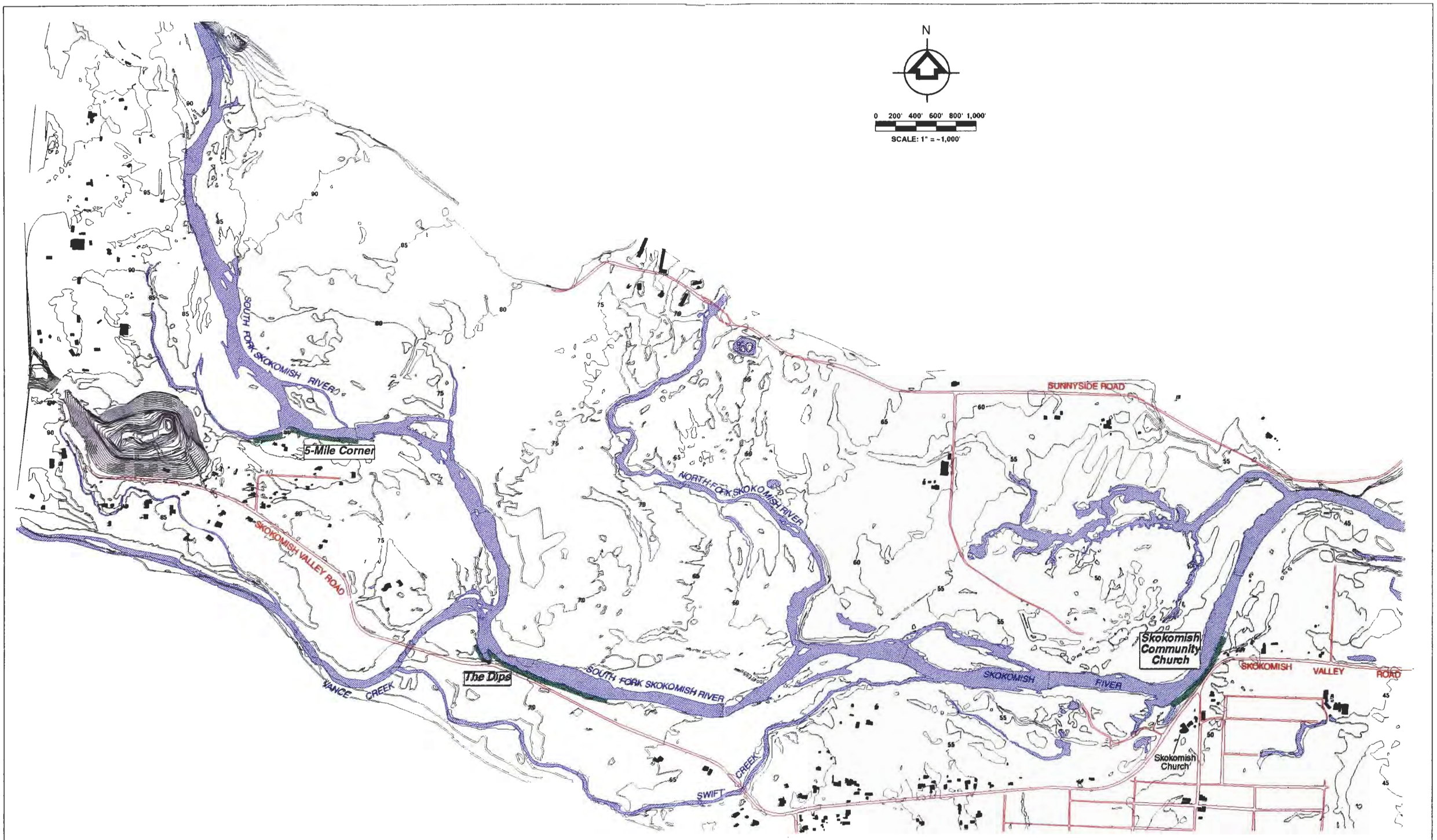

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Figure 6-9.
BANK EROSION PROBLEM AREAS

Recommended Actions

Rock riprap should be used for bank protection on the south bank of the river at Five Mile Corner, the Dips, and the Skokomish Valley Church. The existing riprap at these locations should be reinforced or replaced to strengthen the banks.

The FCZD should initiate a bank protection program. Both banks of the river should be inspected at least from the confluence of the North and South Forks to the mouth of the river. A list of field reconnaissance tasks is presented in Table 6-15. Inspections should take place twice annually, prior to and following flood season.

Areas of existing or newly constructed rock bank protection should also be inspected annually. The toe area should be inspected closely during periods of low water since most conventional bank protection structures fail because of undermining. The following conditions suggest that repairs may be necessary (Johnson and Stypula 1993):

- Areas of bare soil within the toe zone
- Horizontal displacement of individual rocks or sections of rock within the toe zone
- Scour along the toe that results in loss of support to the upper bank
- Evidence of bed degradation, headcuts, or scour holes that might undermine the toe
- Movement or loss of large rock protecting the foundation of cribwalls or movement (settling, tilt, or horizontal displacement) of the structure.

Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Promote programs and strategies that are, to the greatest extent possible, consistent with the Tribe's goal of restoring the Skokomish River watershed through its watershed plan (objective).
- Identify areas where bank stabilization is needed for flood hazard management, and seek funding for bank stabilization efforts (action).
- Recommend that all flood control options implemented be monitored for results and that these results be documented (action).

TABLE 6-15.
FIELD RECONNAISSANCE TASK LIST

1. Measure the dimensions of the eroded bank (length and width; top of bank to the toe; identify the ordinary high water mark).
2. Measure the distance from the top of the eroded bank to nearby buildings or structures.
3. Locate and measure the width of access area (usually driveways, clearings around sides of buildings or existing levees).
4. Note the general characteristics of the river in the project area. This includes general gradient through the project reach (is it steady, or does it change significantly up- or downstream of the site?), channel constrictions, channel width (width/depth ratio), and conditions of bank up- and downstream of project area (i.e., are they eroding or stable?).
5. Examine the size of streambed and gravel bar particles (general distribution and median size class). This provides an indication of sediment transport characteristics during high flows.
6. Note the size of the stream or river, direction of flow, and flow patterns. If possible, make several observations at both low and high flows. Does water flow directly into the eroded bank? Does water flow around a bend? Are there eddy-currents from upstream objects?
7. Note the presence of hardpoints such as bedrock, bridge structures, large boulders or debris jams and how these features affect currents.
8. Identify the amount and types of existing vegetation on the bank in the proposed project area. Note the size, species and condition of large trees near the eroded bank (note the location and approximate number). This information is useful in defining the type of system to be used, completing environmental checklists and permit applications.
9. Note fish and wildlife use and habitat in the area. In addition to improving the design, this information is used for completing environmental checklists and other documents.
10. On the eroded bank, note the general types of soils (e.g., gravel, organic, clay, silt, large cobbles) and the arrangement of soil layers if composite banks are present.
11. Note the condition of the soils in the access area and where heavy equipment will be working. Are soils wet and soft? Will some kind of hardened surface (e.g., crushed rock) be required? Is there a staging area for equipment and material?
12. Prepare a sketch of the site that shows the specific features noted above. It may be helpful to have an assessor's or plat map to define the relationship between the stream, areas of erosion, existing structures, access roads, and property boundaries. A brief search for property corners and road monuments is useful for the survey and for preparing the base map.
13. Establish photo-points and take photographs. Photographs should be composed to aid the designer in completing base maps and designs. the location of the photo-points should be noted on the base map and design plans. Photographs should also be submitted with permit applications or exemption requests. Show the extent of the erosion, its relationship to buildings or other structures, top of bank, and the existing stream conditions (boulders, gravel bars, debris jams). Photograph access sites, and condition of the banks upstream, downstream, and opposite the project site.
14. Examine existing bank conditions for points to begin and end the project. Starting locations will need anchor sites or other protection. The project should end either on a straight bank or on an existing stable feature.
15. Prepare an in-field, preliminary cost estimate. Also consider costs for clearing, access, easements, and permit fees.

SOURCE: Johnson and Stypula 1993

ISSUE 2: DIVERSION OF FLOW FROM THE CUSHMAN HYDROELECTRIC PROJECT HAS CHANGED THE HYDROLOGIC REGIME OF THE RIVER, REDUCING ITS SEDIMENT CARRYING CAPACITY AND CAUSING INCREASED FLOODING

This section presents summaries of material and excerpts from the DEIS for re-licensing of the Cushman Hydroelectric Project. This CFHMP recognizes that the process that culminated in issuance of the DEIS involved an extensive amount of scientific analysis and input from a wide range of stakeholders. As a result, the material presented in the draft EIS was not re-analyzed to determine its technical merit. In addition, it was determined that presentation of a different set of alternatives or a different process for incorporating the many strong and divergent opinions on this subject was not warranted.

(Copies of comments on the DEIS were received during the final stages of preparation of this plan. Due to the extensive amount of material and the timing of its receipt, additional analysis or interpretation included therein was not incorporated into the following discussion.)

Alternatives

Modification to the operation of the Cushman project are being considered as part of procedures being conducted by FERC to evaluate Tacoma Public Utilities' application for a major license. These modifications involve changing the amount of water released from Lake Cushman to the North Fork.

The following is a description of the elements of the three alternatives relating to flood hazard management and the impact expected from implementation of each. The material presented here is based entirely on the DEIS, as it was the most up-to-date and concise source of information available.

Tacoma's Proposal:

- Reservoir Operations: Current operation of project reservoirs would remain unchanged. Between Memorial Day and Labor Day, Lake Cushman would be maintained near the full pool elevation of 738 feet. During the fall, Lake Cushman would be drawn down to its lowest level, typically 712 feet, by the end of November. During severe floods, Lake Cushman can be operated up to elevation 742 feet
- Out-of-Basin Diversion: All flows except those required as minimum instream flow under agreement with Ecology in Section 401 Water Quality certificate
- Minimum Instream Flows: Increased from current 30 cfs to 100 cfs year-round
- Average flow below Dam 2: 100 cfs
- Release flows for silt removal: 48 hours at 300 cfs every third year
- Improvements to mainstem's in-channel conveyance capacity: None
- Nalley Ranch Dikes: No change
- Additional Study: None.

Impact

- Mainstem Channel Morphometry: No noticeable changes in channel morphometry or sediment transport expected since dominant discharge in mainstem generally unchanged. Aggradation and loss of conveyance capacity would continue. Mainstem channel improvement, which would result from USFS watershed restoration efforts in the South Fork Watershed, would be slow to occur and slight
- Water Quantity: Average discharge to the lower North Fork would be 100 cfs and average mainstem flows would be 1,218 cfs. A high degree of flood protection during the high-flow fall and winter period would be provided since Lake Cushman would continue to operate under the current rule curve.

Alternative 2 (JRP Recommendation)

- Reservoir Operations: Lake Cushman's water level would be maintained at or above 723 feet at all times to enhance reservoir fisheries. The difference in available storage between the lowest reservoir level in the Tacoma Proposal and the lowest reservoir level in Alternative 2 is approximately 40,000 acre feet
- Out-of-Basin Diversion: No out-of-basin diversion would occur unless necessary for flood control. Diversions would occur when flows in the mainstem reached 5,000 cfs, the predicted threshold for flooding. All flows under 5,000 cfs would be routed to the North Fork
- Minimum instream flows: 240 cfs for the first 5 years until a flow implementation plan is completed. The plan would include staged interim and final flows, flow release schedules, hydrography, and long-term monitoring
- Average flow below dam 2: 782 cfs ("Dominant flow / average flood" in North Fork estimated at 2,900 cfs)
- Release rates for silt removal: 782 cfs
- Improvements to mainstem's in-channel capacity: Improve by dredging and restoring side-channels. Dredging to conform to modern river engineering principles and maintain river's current meander pattern
- Nalley Ranch Dikes: Remove dikes and restore estuarine conditions to 285 acres of land
- Additional Study: None.

Impact

- Mainstem Channel Morphometry: Sediment transport capacity would increase, with channel deepening and substrate coarsening as a result. Aggradation rates would be reduced by about half, or 0.02 foot per year. Channel meander length, slope, and bank-full width not expected to change appreciably

- Reduction in water surface elevation as a result of dredging expected to be approximately 1 foot at the US 101 bridge during 100-year flood (see discussion in Issue 1)
- Removal of Nalley Ranch dikes would cause higher tidal flows, increasing sediment transport rates in the estuary. Small new tidal channels in the estuary would likely result and could increase river flows in the tidally influenced portion of the river (mouth to RM 3.7). This would likely lead to increased channel depth near the river mouth
- The combined effects of estuary channel development, dredging, increased sediment transport capacity, and South Fork watershed recovery efforts could produce measurable increases in mainstem channel conveyance capacity. These effects would be substantial, long-term, and beneficial in reducing mainstem flooding
- Water Quantity: Average discharge to the lower North Fork would be 762 cfs and average mainstem flows would be 1,881 cfs. By maintaining a higher reservoir level during the winter, the flood reduction benefits of Lake Cushman would be reduced. This would produce a negligible increase in downstream peak flows compared to current operating conditions, but a continued reduction in peak flows compared to scenarios under which the hydroelectric project did not exist
- Combining this reduction in peak flows with the conveyance capacity enhancement effects of dredging and the increased frequency of near-flood flows that would be provided under this alternative makes it "the most effective alternative considered in reducing mainstem flood hazards." There are also, however, potentially adverse environmental effects and a significant loss in hydropower generation associated with this alternative. There is considerable uncertainty regarding the short-term and long-term effects of full flows on existing fish stocks. Some of the river's most important potential for anadromous stock enhancement could be endangered or adversely affected by full flows.

Alternative 3 Staff Recommendation

- Reservoir Operations: Lake Cushman's water level would be maintained at or above 723 feet at all times to enhance reservoir fisheries
- Out-of-Basin Diversion: Continued to a slightly lesser degree than current diversion
- Minimum instream flows: Seasonally varied, ranging from 100 cfs to 400 cfs
- Average flow below dam 2: 240 ("Dominant flow" in North Fork estimated at 400 cfs)
- Release rates for silt removal: 400 cfs for November every year
- Improvements to mainstem's in-channel capacity: Participate in projects to enhance the mainstem's conveyance capacity

- Nalley Ranch Dikes: Remove dikes and restore estuarine conditions to 285 acres of land
- Additional Study: "Final channel capacity enhancement plan" and "final channel maintenance flow study report," 25,000 acre-feet of water per year available for delivery to the mainstem for up to 5 years to evaluate effects of augmented flows on channel capacity.

Impacts

- Mainstem Channel Morphometry: No flow-induced effects on channel morphometry or sediment transport are expected in the mainstem downstream of the confluence because flows would not substantially increase mainstem high-flow frequency
- Tacoma would participate in implementing priority projects developed in Mason County's Final CFHMP to increase the mainstem's conveyance capacity. Completion of these projects should measurably enhance the mainstem's conveyance capacity and provide long-term flood hazard reduction benefits to residents and property owners along the mainstem. Possible measures developed in the draft CFHMP included selective gravel deposit removal, overbank channel restoration, side-channel enhancement, river bank stabilization, widening the openings through US 101, debris blockage removal, and local drainage improvements
- "Tacoma would consult with the Tribe, EPA, the Corps, WDOE, WDFW, Mason County, and FEMA to identify cost-effective measures to increase the Skokomish River's conveyance capacity and thereby reduce the human health and welfare risks from flooding." Within 1 year of license issuance, Tacoma would submit to FERC a "final channel conveyance capacity enhancement plan" including:
  - recommended measures to reduce flood hazards to an acceptable level
  - cost estimates for the selected measures
  - options for financing the project(s) including Tacoma's proposed level of contribution
  - any comments on the report from plan participants
- Increasing the length of time that near-flood flows occur could help maintain and enhance the mainstem's conveyance capacity. Under this alternative, Tacoma would also conduct an investigation of channel maintenance flows in consultation with the Tribe and the agencies. Tacoma would make up to 25,000 acre-feet of water per year available for delivery to the mainstem for up to five years to facilitate evaluation of the effects of augmented flows on Skokomish River channel capacity. Such releases would be managed to avoid downstream flooding. The 25,000-acre-foot allotment would provide five days of continuous flow at 2,500 cfs (about half of the mainstem's current conveyance capacity). Tacoma would provide a "final channel maintenance

flow study report" to the Commission within six years of license issuance. The report would include the following:

— a discussion of the effectiveness of channel maintenance flows in maintaining the mainstem's conveyance capacity

— a recommendation to continue or abandon efforts to maintain the river's capacity through flow manipulation

- Water Quantity: Average discharge to the lower North Fork would be 229 cfs and average mainstem flows would be 1,348 cfs. "Because this alternative includes the same reservoir rule curve and minimum release rate during downstream flooding as Alternative 2, the project's effects on peak flows with the conveyance capacity enhancement effects of implementing projects in Mason County's Final Flood Hazard Reduction Plan would make this alternative highly effective in reducing mainstem flood hazards."

Analysis Approach

No analysis was completed for this CFHMP. Analysis relating to the alternatives are described in the DEIS.

Analytical Conclusions

The following analytical conclusions are taken from the DEIS. These conclusions relate specifically to the channel morphometry and water quantity impact of each of the three alternatives:

> Much of the mainstem's historical conveyance capacity has been lost due to aggradation (Simons and Associates, 1993; Jay, 1994). The two principal causes of mainstem aggradation are reduced peak flows caused by the Cushman Project, and increased sediment loads, mostly from extensive logging in the South Fork watershed. Other factors contributing to flooding in the Skokomish Valley include the filling of side channels and tidal sloughs, highway fills that traverse the valley, and inadequate road drainage.
>
> Reducing sediment loads and increasing the length of time that near-flood flows (about 5,000 cfs) occur would gradually increase the channel capacity. Channel manipulation could be used to accelerate these natural processes but cannot replace them. Mechanical channel manipulation (dredging and diking), without concurrent reductions in sediment loads or increases in sediment transport rates, would only temporarily improve channel conditions (Corps, 1995). Over time the river would naturally adjust to hydrologic and sediment regimes.
>
> Erosion control efforts currently underway by the Forest Service in the South Fork watershed should eventually reduce sediment loads reaching the mainstem. If this program substantially reduces mainstem sediment loads, existing aggradation rates could be reduced or arrested.
>
> We conclude that the Cushman Project has contributed to aggradation in the mainstem Skokomish River and that these effects increase the severity of flood effects (overbank flows). It is also true, however, that flood flow attenuation in Lake

Cushman reduces mainstem flood peak flows. Overall, the Cushman Project reduces flooding along the mainstem (Tacoma, 1994).

[The TPU Proposal] does not propose any measures to increase the mainstem's conveyance capacity. There would be no project-related change in the mainstem's aggradation rate or conveyance capacity.

By combining mechanical conveyance improvements with more frequent near-flood flows, as recommended by NMFS, WDFW, and the Tribe, Alternative 2 would have the largest effect on reducing mainstem flood hazards of the alternatives considered. This proposal, however, also has some potentially severe negative environmental effects.

We conclude that because aggradation in the lower Skokomish River causes higher flood water levels and because mainstem aggradation is partially attributable to Cushman Project operations, Tacoma should participate in Mason County Flood Hazard Management Plan projects to increase the Skokomish River's conveyance capacity. This measure is therefore included in Alternative 3.

Tacoma should consult with the Tribe, EPA, the Corps, WDOE, WDFW, Mason County, and FEMA to identify cost-effective measures to increase the conveyance capacity of the mainstem and to minimize property damage and human health risks from flooding on the Skokomish River.

Under Alternative 3, Tacoma's provision of up to 25,000 acre-feet of water to extend the length of time that the mainstem is at near-flood levels would facilitate a study to evaluate the effects of augmented flows on Skokomish River channel capacity. If this measure is effective at maintaining mainstem channel capacity, it should be extended to occur throughout the new license period. If this measure is unsuccessful, Tacoma should develop or participate in a mainstem capacity maintenance program.

The Cushman Project has long-term beneficial effects on peak flows downstream from the project. Peak flows would be similar under all of the alternatives except decommissioning. Alternatives 2 and 3 would have the most significant beneficial effects on downstream flood hazards because they combine the peak flow reducing effects of the project with the mainstem conveyance capacity enhancement. Due to the long term channel maintenance benefits provided by frequent near-flood flows in the mainstem, Alternative 2 would provide the highest flood hazard reduction benefits of the alternatives considered. This benefit would result in a significant loss of hydropower generation and would cause significant adverse environmental effects.

DOI, WDFW, FWS, and NMFS recommend that, to verify compliance with recommended streamflow conditions, Tacoma establish telemetered streamflow gauging stations on the North Fork within 1 mile downstream from Dam No. 2, on the South Fork just upstream of its confluence with the North Fork, and on the mainstem immediately downstream from the confluence of the North and South Forks.

We agree that streamflow monitoring is necessary to demonstrate compliance with MIF [minimum instream flow] requirements and that improvements in the existing stream gauge network are needed. We therefore conclude that Tacoma, in

> consultation with USGS, should telemeter the existing North Fork stream gauges (USGS Stations No 12058800 and 12059500) and re-establish a telemetered stream gauge at the abandoned USGS Station No. 12060500 on the South Fork. USGS Station No. 12058800 would be needed to demonstrate compliance with our recommended MIFs. The recommended actions on the lower North Fork and lower South Fork would be useful for the recommended channel maintenance flow program and would improve mainstem flow and flood forecasting.

County and PAC Communications on the Cushman Project

Recommendations for the future operation of the Cushman Project and mitigation of flood-related impacts presented below are based on communications prepared by the PAC and the County Commissioners.

A draft letter addressed to FERC was prepared by the Skokomish Tribe and presented to the PAC for comment during the May 18, 1995, PAC meeting. The draft letter was prepared for the County Commissioners to consider signing and sending to FERC as their own comments. A copy of the draft is included with this report as Appendix Y. The draft letter states that a goal of the CFHMP is to

> restore and maintain the water and sediment carrying capacity of the Skokomish River system. This is necessary to reduce flood hazard to life and property and to restore natural watershed/ecosystem functions in the Skokomish River and Hood Canal. Consistent with this goal, objectives of the Plan include: 1) Change Cushman Project operations to enhance flood control, including elimination of the Project's contribution to main stem channel aggradation; and 2) reduce unnatural contribution of sediment to the river system from forest management activities.
>
> The Skokomish Tribe and Federal and State resource agencies have recommended to FERC that North Fork streamflow be restored in a way that substantially restores watershed/ecosystem functions, and reduces channel aggradation, concomitant flooding problems and risk of accelerated channel migration. The County supports this strategy for substantial restoration of North Fork flow as essential to reduce or eliminate Cushman Project contributions to future channel aggradation. The County recommends that substantial restoration of North Fork flow retain/enhance flood storage provided by the Cushman Project and that high summer recreation pool levels be maintained in Cushman Reservoir as recommended by the Skokomish Tribe. Operational testing/monitoring necessary to implement the restored North Fork flows should identify additional measures that may be needed to restore water and sediment carrying capacity of the channel, including dredging (Martino, 1995).

The PAC had several comments following presentation of the letter. A copy of relevant sections of the minutes from the meeting is included in Appendix Y. It was agreed at the meeting that the letter would be changed to make it clear that flow releases should be provided in a way that would maintain or enhance the present level of flood control provided by the Cushman Project and that Mason County staff would present the finalized letter to the County Commissioners. A copy of the revised letter was not available at the time of preparation of this plan.

On June 2, 1995, the Skokomish Tribe sent a letter to FERC concerning to the Skokomish River CFHMP preliminary goals and objectives. The letter indicates that "the Planning Advisory Committee unanimously approved for incorporation in the Flood Plan specific goals and objectives related to upstream activities, including operation of the Cushman Hydroelectric Project." Two paragraphs from the Tribe's letter of March 18 (see above) are then presented. The letter also describes and includes as an attachment the "Key Elements" adopted by the Planning Advisory Committee (see Chapter 1).

On June 13, 1995, the Mason County Board of Commissioners sent a letter to FERC describing the status of the CFHMP. A copy of the complete letter is included with this report as Appendix Y. The letter states that the CFHMP

> recognizes the link between upstream watershed activities, including the Cushman Hydroelectric Project, past forest land management, and flooding problems in the Valley.
>
> An important goal in the Plan is to restore and maintain the water and sediment carrying capabilities of the River system. This is necessary to reduce flood hazard to life and property and to restore natural watershed/ecosystem functions in the Skokomish River and Hood Canal. The plan will include recommended strategies for addressing upstream watershed activities.
>
> The Board has included a list of elements that have been adopted by the Skokomish Valley Comprehensive Flood Hazard Management Plan Planning Committee. These elements will be included as either objectives or actions. We request that these be given full consideration in the Federal Energy Regulatory Commission's environmental review and licensing process (Mason County Board of Commissioners 1995).

At the June 15, 1995, meeting, Mason County staff indicated to the PAC that the Board of Mason County Commissioners had sent a letter to FERC, notifying FERC of the County's work on the CFHMP. It was reported that the list of Key Elements was attached, and that the letter sent by the Commissioners was a revision of the letter that the PAC had agreed to and asked the Commissioners to sign.

Recommendations

This CFHMP supports recommendations to the Federal Energy Regulatory Commission by the Skokomish Tribe and state and federal resource agencies that managed flow releases from the Cushman Project be required that will substantially restore river and estuary fish habitat conditions and the mainstem's natural sediment carrying capabilities. Managed flow releases would be designed to effectively treat unnaturally high rates of channel aggradation in the mainstem Skokomish River and restore to the maximum extent practicable the natural sediment carrying capabilities of the mainstem. Managed flow releases from the Cushman Project—not to exceed bankfull levels on the mainstem—should be determined by a program of testing and monitoring, which would also identify the extent to which mechanical removal of accumulated bedload, including gravel bar removal and instream dredging, may be necessary to restore mainstem channel capacity. Any instream dredging project should be supported by good science, shown to be beneficial for fish life and habitat, and be supported by a consensus of local, tribal, state and federal regulatory and concerned agencies and community.

Based on existing information, Mason County and the Skokomish Tribe believe that mechanical removal of accumulated bedload will be required—in combination with managed flushing flows—to fully and expeditiously restore the mainstem's capabilities to carry water and sediment.

There is uncertainty about the effect that managed flushing flow releases to the North Fork will have on flushing accumulated bedload from the mainstem river. Therefore, this CFHMP supports pilot testing of enhanced sediment transport through controlled releases from the Cushman Project to determine optimum flushing flows and the extent that mechanical removal of accumulated bedload will be necessary to restore channel capacity and the related objective of lowering groundwater levels. Mason County and the Skokomish Tribe believe that mechanical removal of accumulated bedload will be required—in combination with managed flushing flows—to fully restore mainstem channel capacity. Careful monitoring should be an integral part of the testing of the controlled releases to evaluate effects on sediment transport, bed elevation, channel capacity, and groundwater levels. Results should be made available to the PAC and all valley residents.

The Cushman Project has historically provided substantial flood hazard management benefits (see Chapter 4). This CFHMP strongly recommends that, regardless of the changes made to the operation of the facility to enhance sediment transport or fisheries habitat, the project continue to provide flood protection from extreme events. This protection should be achieved by limiting releases to the North Fork so that flows in the lower mainstem do not exceed 5,000 cfs, the approximate channel capacity in the vicinity of US 101.

Since the operation of the Cushman Project has adversely affected flooding in the Skokomish Valley, this CFHMP supports allocation of a portion of mitigation funding for completion of County-sponsored flood hazard management projects. The County should work with FERC and TPU to develop an appropriate program of projects and level of funding. Priority should be given to projects recommended in this CFHMP.

The recommendations presented above, or in the DEIS, will not, by themselves, eliminate flood hazards in the Skokomish Valley. Neither will coupling any of these actions with any level of gravel removal eliminate flood hazards in the Skokomish Valley. Implementation of the recommendations presented here, in conjunction with the other recommendations in the plan, will reduce, not eliminate, flood hazards. Residents should understand and take appropriate individual action in dealing with the flood hazards that will always be present in the Skokomish Valley. These actions must be taken regardless of positive changes in upper watershed conditions, such as in the operation of the Cushman Project.

Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).

- Promote programs and strategies that are, to the greatest extent possible, consistent with the Tribe's goal of restoring the Skokomish River watershed through its watershed plan (objective).
- Incorporate existing information from other plans to provide direction in completing a plan for the Skokomish Valley, including the Skokomish Tribes Watershed Restoration Plan (when completed), the watershed plan of the Hood Canal Ranger District (when completed), Ecology's 1988 Draft, Skokomish River Comprehensive Flood Hazard Management Plan, and other documents that may prove relevant (objective).
- Address the impact that diversion of North Fork flows out of the basin has had on the bedload transport capacity of the mainstem Skokomish River (issue).
- Promote and seek funding for gravel removal strategies to improve the hydraulic performance of the River (action).
- Recommend that all flood control options implemented be monitored for results and that these results be documented (action).

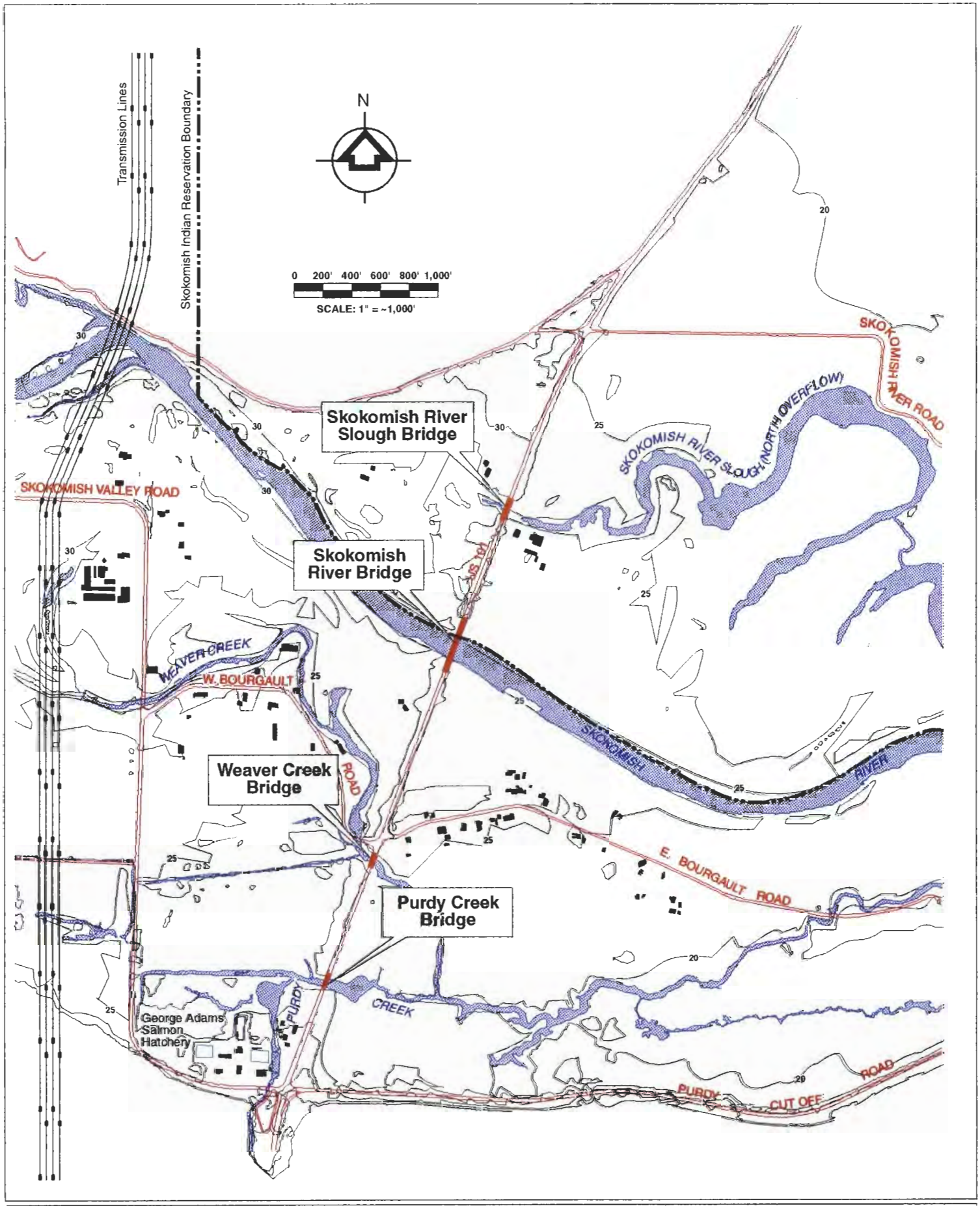
ISSUE 3: US 101 CAUSES LOCALIZED INCREASES IN FLOOD LEVELS

The existing US 101 embankment has four bridge openings, as shown in Figures 6-10 and 6-11. Moving from north to south, they are the Skokomish River Slough Bridge (Overflow Bridge), the Skokomish River Bridge, the Weaver Creek Bridge, and the Purdy Creek Bridge. During extreme flood events, Skokomish River floodwaters are conveyed under all four bridges. During less severe events, the overflow bridge may not convey any of the Skokomish River, and the Weaver Creek and Purdy Creek Bridges only runoff from their respective creeks. Under these less severe events, therefore, the Skokomish River Bridge is able to convey the entire flow in the river.

During the December 20, 1994, flood event, floodwaters from the river overtopped the banks and levees upstream of US 101 and flowed across the valley toward the southern section of the US 101 embankment. Within 8,000 feet upstream of US 101, the elevation of the valley is lower on the south side than on the north side. Therefore, floodwaters leaving the river banks naturally flow toward the south side of the valley. Once this occurs, the Weaver Creek and Purdy Creek Bridge openings convey much of the Skokomish River flow through the highway embankment. As was observed during the December 20 flood event, the combined conveyance capacity of the Purdy Creek and Weaver Creek bridge openings is not sufficient for these overbank flows. A substantial amount of the overbank flows end up flowing over the roadway above the Purdy Creek opening, forcing closure of this section of the highway.

Alternatives

Several alternatives were modeled using HEC-2 to document the effect of enlarging bridge openings on the flow distribution through the openings and on the upstream water surface elevations. Each alternative was designed to improve the hydraulic efficiency of one or more of the four bridge openings. The effectiveness of each scenario was determined by comparing the results against the 100-year existing conditions results.



KCM
1917 First Avenue
Seattle, Washington 98101

Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 6-10.
HIGHWAY 101 BRIDGES

KCM
1917 First Avenue
Seattle, Washington 98101

Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 6-11.
HIGHWAY 101 VICINITY

Alternative 3A—Remove US 101 Embankment

The purpose of modeling this alternative was to document the effect of the US 101 embankment on flood levels in the Valley. The entire embankment was removed from the model.

Alternative 3B—Increase Conveyance Capacity of Northern Overflow, Raise US 101 over Purdy Creek and Enlarge Purdy Creek Bridge Opening

This alternative addressed the Skokomish River Slough Bridge opening (northern overflow) and the Purdy Creek bridge opening. Upstream of the northern overflow bridge, the vegetation is dense, with woody debris and standing trees. The slough is blocked by woody debris where it splits from the main channel, and the bridge opening itself is blocked by debris and overgrown by brush. One of the goals of this alternative was to document the effect of increasing the hydraulic efficiency of the overflow channel upstream of the Skokomish River Slough Bridge. In the model, increased hydraulic efficiency was simulated by decreasing the roughness coefficient of the overbank upstream of the bridge opening. In the field, increased hydraulic efficiency would be achieved by selectively removing woody debris, clearing the brush from around the bridge opening, and removing blockages in the slough.

This alternative also included increasing the size of the Purdy Creek Bridge and raising the roadway over the creek. Currently, the lowest elevation of the roadway over the creek is 29.7 feet. During extreme events, such as on December 20, floodwaters are conveyed over the roadway, resulting in weir flow approximately 2.5 feet deep at the deepest location. For this alternative, the top of road elevation was raised to 35.0 feet, matching the roadway elevation over Weaver Creek, thus eliminating the dip in the roadway that currently exists over Purdy Creek. Along with raising the roadway, the bridge opening was enlarged so that the water surface elevation resulting from the 100-year flood event is conveyed beneath the low chord of the bridge. To accomplish this, the bottom width of the bridge opening was nearly doubled and the net open area of the bridge was increased by a factor of three.

Alternative 3C—Increase Conveyance Capacity of Northern Overflow, Enlarge Main Channel Bridge Opening

Alternative 3C, like Alternative 3B, investigated the effect of increasing the hydraulic efficiency of the northern overflow in conjunction with increasing the open area of one of the other bridges. In this case, the net open area of the main channel bridge was increased by a factor of 1.5. The assumptions used in Alternative 3A for the overflow clearing also apply to this alternative.

Alternative 3D—Increase Conveyance Capacity of Northern Overflow, Raise US 101 over Purdy Creek and Enlarge Purdy Creek Bridge Opening, and Enlarge Main Channel Bridge Opening

This alternative combined Alternatives 3B and 3C. More capacity was created for flow in the northern overflow channel, the net opening of the Purdy Creek bridge was increased by a factor of three, and the roadway was raised to elevation 35.0. In addition, the net open area of the main channel bridge opening was increased by a factor of 1.5.

Analysis Approach

The analysis approach consisted of an initial determination of the distribution of flows through the four bridge openings under current conditions, followed by development of HEC-2 model files and simulation of the four alternatives.

Current Conditions Distribution of Flow

Before the alternatives could be modeled, the distribution of flows under existing conditions had to be determined. All hydraulic analysis of the bridge openings was conducted using the FEMA 100-year flow rate of 34,910 cfs. For comparison, using flow data from the USGS and TPU, KCM estimated the December 20, 1994, flood peak to be about 34,500 cfs (see above). Using the current FEMA flood frequency curve, the December 20 event was about a 100-year flood event.

The HEC-2 model was calibrated using the high-water marks from the December 20 flood event and a flow rate of 34,500 cfs. Once the models were calibrated, the FEMA 100-year flow rate of 34,910 cfs was run through the model to establish the existing conditions. The results of the bridge opening analysis for current conditions during the 100-year flood are presented in Table 6-16.

Approximately 36 percent of the total flood flow is conveyed through the main channel bridge opening. Nearly the same amount flows toward the Purdy Creek Bridge. Therefore, the main channel bridge opening is being under-utilized, not through any deficiency in design, but because the low topography on the south side of the valley causes overbank flows to flow toward the Purdy Creek and Weaver Creek Bridge openings.

Computer Simulations

Four separate HEC-2 models were developed to simulate the previously described alternatives. The HEC-2 model changes were described above.

TABLE 6-16.
CURRENT CONDITIONS ANALYSIS—DISTRIBUTION OF FLOWS THROUGH US 101 EMBANKMENT DURING 100-YEAR FLOOD EVENT

	North Overflow	Main Channel	Weaver Creek	Purdy Creek	Total
Flow Rate (cfs)	2,510	12,640	6,840	12,920	34,910[1]
Percent of Total[2]	7%	36%	20%	37%	100%
Head Loss (feet)[3]	0.9	0.7	2.1	1.0	

1. Total flow rate equals FEMA 100-year flow rate of 34,910 cfs.
2. The Purdy Creek flow rate includes approximately 10,000 cfs over the roadway.
3. Head loss generally equals the difference between upstream and downstream water surface elevations.

Analytical Conclusions

Three calculations of interest at each of the four bridge openings can be compared to assess the effects of each of the alternatives on the hydraulics of the river and to reach some general conclusions on the role of the four openings during extreme flood events. The flow distribution through each of the openings, as a value and a percentage of the total, is probably the most important piece of information. The two other data include head loss through the bridge openings, and the resulting upstream water surface elevations. Table 6-17 presents the results of the modeling for the US 101 scenarios, allowing the data to be compared.

The head loss varies through each of the bridge openings due to the flow rate through the bridge, the geometry of the bridge structure and channel, and the pier spacing under the bridge. The value reported in the Table 6-16 is the largest computed for each bridge. The maximum head loss affects upstream water surface elevations. If the maximum head loss decreases under a particular alternative, then upstream water surface elevations would also decrease.

TABLE 6-17.
RESULTS OF MODELING US 101 ALTERNATIVES

	Existing	Scenario 3A	Scenario 3B	Scenario 3C	Scenario 3D
Maximum Head Loss (feet)	2.1 feet (at Weaver Creek)	N/A	3.4 feet (at Purdy Creek)	2.0 feet (at Weaver Creek)	3.4 feet (at Purdy Creek)
WSEL at Section 31 (Reduction from existing conditions)[1]	33.4	31.5 (1.9)	33.0 (0.4)	33.2 (0.2)	32.9 (0.5)
WSEL at Section 40[2]	41.3	41.3	41.3	41.3	41.3
Q in North Overflow, cfs (% of Total)[3]	2,510 (7.2%)	N/A	3,480 (10.0%)	3,930 (11.3%)	3,360 (9.6%)
Q in Main Channel, cfs (% of Total)[3]	12,640 (36.2%)	N/A	11,310 (32.4%)	12,610 (36.1%)	11,610 (33.3%)
Q in Weaver Creek, cfs (% of Total)[3]	6,840 (19.6%)	N/A	6,220 (17.8%)	6,570 (18.8%)	6,135 (17.6%)
Q in Purdy Creek, cfs (% of Total)[3]	12,920 (37.0%)	N/A	13,900 (39.8%)	11,800 (33.8%)	13,805 (39.5%)

1. Section 31 is approximately 1,000 feet upstream of US 101. Elevation datum is NAVD88.
2. Section 40 is approximately 7,500 feet upstream of US 101. Elevation datum is NAVD88.
3. Total flow rate is the FEMA 100-year flow rate of 34,910 cfs.

Under existing conditions and Alternative 3C, the maximum head loss occurred at the Weaver Creek Bridge; under Alternatives 3B and 3D, the maximum head loss occurred at the Purdy Creek Bridge. Head loss increased to nearly 3.5 feet at Purdy Creek due primarily to the fact that all of the flow conveyed over the top of the road was forced through the bridge opening.

Under existing conditions, the flow over the road extended to a top-width of nearly 1,200 feet, but under the alternatives where the overflow was eliminated, roughly the same magnitude flowed through the bridge opening. The smaller flow area through the bridge resulted in higher velocities, and hence higher frictional and contraction/expansion losses, which translate into higher head losses.

Other conclusions are as follows:

- As seen from a comparison of results from the existing conditions simulation and scenario 3A (removal of US 101 embankment), the US 101 embankment across the Skokomish Valley exacerbates flooding. It causes flood levels upstream of the highway to increase as much as 1.9 feet, near the Weaver Creek Bridge. This increase is localized, however, with flood levels decreasing upstream from the highway. The embankment has no measurable effect about 7,500 feet upstream.
- Implementation of each of the other alternatives would affect the water surface elevations immediately upstream of the bridge openings and the distribution of the flow rates through each of the four openings. As seen in Table 6-17, the water surface elevations approximately 1,000 feet upstream of the bridge vary by alternative. Reductions in flood levels in this area varied from about 0.2 to 0.5 feet for the three alternative scenarios investigated.

  At locations approximately 7,500 feet upstream of the bridge, the water surface elevation is the same no matter which alternative is considered. The localized effect of the increased water surface elevation is due to the fact that modifications made to the hydraulics of a channel will propagate upstream only a finite distance. Further upstream of this point the water surface elevation returns to its normal elevation.
- While reductions in flood levels during extreme floods are relatively small for the three scenarios investigated, larger bridge openings at Weaver and Purdy Creeks would still provide a benefit by draining the valley faster as flood flows recede.
- The Purdy Creek Bridge and highway overflow convey about as much flow during an extreme flood as the main bridge opening for the Skokomish River. This is because ground elevations along the south end of the valley, upstream from the highway, are lower than along the north side, causing overbank flow in the valley to flow south toward Purdy Creek rather that toward the bridge for the main channel. Widening the main channel bridge alone will not result in more flow being directed through the main channel bridge.

  Alternatively, if the riverbed through this reach is lowered, more flow will remain in the channel rather than overflowing toward the south side of the valley. This would result in more flow passing through the bridge opening. However, the location of the bridge in a depositional reach of the river will require maintenance removal of sediment to perpetuate the expected benefits. (Additional details on channel widening upstream of the embankment were presented in Issue 1.)

- The alternatives that investigated modifying the Purdy Creek bridge included both enlarging the bridge opening and raising the road elevation above the bridge opening. In contrast, if the roadway was raised without enlarging the bridge opening, the 10,000 cfs that had been conveyed over the top of the road would have to flow through the existing bridge opening. This would result in higher upstream water surface elevations than under existing conditions. Hydraulically, it is more efficient to convey the flow over the top of the road than through a bridge opening. Regionally, overflow of US 101 near Purdy Creek is an important flow path during extreme floods. Therefore, eliminating the overflow over the roadway should always be accompanied by increasing the net open area of the bridge to continue to allow for floodwater conveyance without increasing flood levels upstream of the highway.
- Any efforts to increase the opening of the Purdy Creek bridge should be undertaken only after careful consideration of the hydraulics of the four openings through the embankment. If the Purdy Creek opening is made too large, more flood flow will be conveyed through Purdy Creek and less through the main channel bridge. The effect of increasing the Purdy Creek bridge opening is greater on redistributing flow than on lowering flood levels.
- None of the alternatives that looked at increasing the net area of the main channel bridge resulted in conveying more flow through the bridge opening than is currently conveyed. This is due mostly to the fact that the flows through the main channel bridge opening are not controlled by the bridge opening itself, but by the upstream overbank flow and the fact that it is hydraulically more efficient for overbank flows to move through the southern two bridge openings since they are at the lowest elevation of the valley.
- The south side of the Valley, upstream from US 101, is a major flow path for overbank flow. This flow corridor should be kept free of obstructions to flow.
- Modifications to any of the openings through the US 101 embankment should be undertaken only after consideration of the impact on residents downstream of the highway.

Recommended Action

While the benefits of the alternatives are limited, they do produce a localized reduction in flood depths. Reductions in upstream flood depths resulting from these alternatives are expected to be permanent. This localized reduction in flood depths, when combined with benefits from other alternatives, will provide a reduction in flood damage. Therefore, modification to the US 101 embankment and bridges are recommended according to the scenario presented in Alternative 3D. A pre-engineering design should be completed in coordination with mainstem channel restoration proposals to evaluate alternative methods and their costs and flood benefits for the following US 101 modifications:

- Increase capacity in the north overflow by selective removal of woody debris and brush near the bridge opening and in the slough
- Raise the roadway near Purdy Creek to an elevation of 35 feet and increase the opening under the Purdy Creek bridge by a factor of three

- Increase the main channel bridge opening by a factor of 1.5.

This alternative should be implemented by WSDOT, which maintains jurisdiction over US 101. Mason County should provide project coordination, involve any other relevant parties, and coordinate funding.

The recommendation is predicated on the following:

- The roadway adjacent to the Purdy Creek Bridge should not be raised without enlarging the bridge opening.
- Any enlarged bridge opening at Purdy Creek should have at least the same hydraulic capacity as the combined flows at the existing Purdy Creek bridge and the adjacent US 101 overflow (a total of approximately 12,900 cfs).
- Any enlarged bridge opening at Purdy Creek should not be made so large that it will result in a dramatic re-distribution of flows through the openings at US 101.
- The area within approximately 1,000 to 2,000 feet of the Purdy Creek Bridge should be kept as open as possible to allow conveyance of floodwaters during extreme events.
- Modification of the openings in the US 101 embankment should be implemented only after careful consideration and mitigation of potential impact downstream property.

Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).

ISSUE 4: SR 106 CAUSES LOCALIZED INCREASES IN FLOOD LEVELS

SR 106 crosses the Skokomish River and floodplain approximately 1.5 miles upstream of the mouth of the river. The highway is located on Tribal land between US 101 and the west bank of the river. Tribal land along the highway is elevated relative to the floodplain within 1,000 feet of the channel. The alignment of the road, across the floodplain perpendicular to the direction of flow of the river, suggests that it may exacerbate the effects of flooding.

Development and analysis of alternatives to mitigate potential flood effects of SR 106 was beyond the current scope of this CFHMP. However, the following is a brief summary of alternatives that might be considered in the future and the procedure that should be followed to analyze the alternatives.

Alternatives

Alternatives that should be considered to mitigate increases in flood levels all include increasing the effective area through which floodwaters can be conveyed. A pre-engineering design should be completed—in coordination with mainstem channel restoration proposals—to evaluate the costs, flood benefits and environmental effects of the following two alternatives.

- Remove the entire embankment east of the intersection of Skokomish River Road and SR 106, in the area of deepest flooding. Replace the embankment with an elevated causeway
- Enlarge the bridge opening.

Alternative Analysis

No analysis was completed.

Analytical Conclusions

No analysis was completed.

Recommended Action

Further analysis should be completed to determine to what extent SR 106 exacerbates flooding. The analysis should be completed using the calibrated HEC-2 model and a range of flood frequencies. Changes in flood levels resulting from each alternative should be analyzed to determine which of the above alternatives can reduce flooding.

Key Element

The following key element addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Identify areas that cannot be adequately addressed in the current Plan due to funding and time constraints, and recommend that these areas be phased into the Plan as practical (action).

ISSUE 5: FLOODWATERS ARE NOT ADEQUATELY CONVEYED BACK INTO THE RIVER FOLLOWING FLOOD EVENTS

The drainage network in the Valley consists of well-defined creeks and less-well-defined channels and unnamed creeks. The drainage network provides conveyance of water in the Valley for flow conditions ranging from low, base flows to extreme flood events that inundate the entire Valley. During low-flow conditions the drainage network collects runoff from the surrounding hills and conveys this water across the Valley to the Skokomish River. During storm events, even when overbank flood conditions are absent on the Skokomish River, the drainage network prevents local flooding and ponding in the Valley. For both low-flow conditions and storm events the drainage network serves to convey water from the Valley, lowering groundwater levels and making the land more productive for farming.

During extreme flood events, flows overtop the banks of the Skokomish River. The drainage network serves many purposes as the flood rises and recedes. As the flood levels rise and begin to overtop the banks of the Skokomish River, the drainage network minimizes the extent of initial Valley flooding. As flood levels continue to rise, the creeks are submerged along with the remainder of the Valley. Even in this submerged condition the creeks provide the major overbank flow corridors across the Valley. Finally, as floods recede and water levels drop, the drainage network provides an efficient route for water leaving the Valley.

There are three existing conditions in the Valley that inhibit the efficient flow of floodwater across the Valley and therefore worsen the flood hazard. First, the construction of US 101 across the Valley has caused flood levels to increase upstream from the highway. During extreme flood events Valley residents have observed differences in flood levels from one side of the highway to the other. Second, debris blockages in the creeks are major obstacles to flow during floods. While woody debris and vegetation are critical to a productive creek network for the fisheries resource of the Skokomish River, large blockages create a flood hazard by causing creeks to overtop their banks and flood surrounding areas. For the flat Skokomish River Valley, overbank creek flow can spread and flood a relatively large area. Third, obstacles to internal drainage from the fields to the drainage network cause local flooding and extend the duration of ponded water in the Valley.

Alternatives

A well-maintained drainage network in the Valley minimizes flood hazards and provides benefits for all flow conditions. Alternatives for maintaining the drainage network include the following:

- Removing overbank vegetation along creek reaches upstream of US 101
- Removing excessive debris blockages in creeks
- Improving the hydraulic efficiency of openings through the US 101 embankment or enlarging the openings through the embankment
- Improving internal drainage in the Valley
- Designating the main flood flow corridors across the Valley as floodways to prevent possible future obstruction of these flow paths.

Analysis Approach

While no quantitative hydrologic or hydraulic analysis was completed for this alternative, conditions in the Valley that affect the conveyance of floodwater back to the river following flood events were examined using available topographic mapping, aerial photographs, field inspection, and interviews with local residents.

Analytical Conclusions

The conclusions presented in this section are largely from information and conclusions originally presented in the 1993 Draft CFHMP. While conditions relating to overbank vegetation, debris blockages, and internal drainage may vary from year to year at the specific locations, it is expected that many, if not all, of these recommendations remain relevant. The

overall recommendation is that a program of annual inspections and maintenance should be conducted to document problems and develop and implement solutions in these areas.

Overbank Vegetation Removal

During flood events, the openings through the US 101 embankment for Purdy and Weaver Creeks restrict flow. (The hydraulics of this occurrence were discussed in Issue 1.) At low flows and for small floods the effect of the openings on upstream flood levels is less than for extreme floods that inundate the entire Valley. As flood levels rise the highway embankment inhibits flow and water begins to pond upstream from the bridge. During the 1990 flood, then the largest Skokomish River flood on record, flood waters overtopped the highway embankment.

To mitigate the impact of US 101, the hydraulic efficiency of the channel approaches to the openings should be improved. This can be accomplished by selectively removing vegetation from the overbank areas upstream of the openings. While not posing a problem during low flows, this vegetation obstructs flow during extreme floods when the Valley is inundated. Flow obstructions at the openings also increase the amount of time it takes for floodwaters to drain from the Valley after a flood peak has occurred and flood levels are receding. Even minor clearing in these areas will improve the hydraulic performance at these openings. WSDOT should be contacted to undertake this maintenance activity on a regular basis, at least annually.

Debris Blockage Removal

Excessive debris has accumulated at various locations in Hunter, Weaver, Purdy, Beaver, and other, unnamed, creeks. These blockages create a flood hazard by restricting flow and increasing flood elevations in the creeks. During a high flow event these blockages commonly increase in size as additional debris is transported by the flood, and may break loose and obstruct the creek channel farther downstream at a more critical location, such as a bridge opening. The CFHMP recommends that excessive debris blockages be removed on an annual basis.

KCM met with residents of the Skokomish River Valley on March 5, 1993, to inspect locations considered to have creek blockages causing a flood hazard. Following this initial field inspection, KCM, on March 8, 1993, met with Mr. Jim Fraser of WDF (now WDFW) and Ms. Margie Shirato of the Skokomish Tribe to revisit the creek blockages and obtain the viewpoint of WDF and the Tribe on removal of identified blockages. In addition to examining specific locations of concern, the purpose of these field inspections was to walk through the first stage of the regulatory process for creek activities. The meeting also demonstrated the commitment of WDF to meet with Valley residents and provide advice and cooperation in addressing flood hazard concerns. This cooperation and trust is necessary in developing a maintenance program for the Valley creeks that eliminates flood hazards and enhances riparian and fisheries habitat.

Eight sites were inspected during each field visit, as shown in Figure 6-12 and described in the following:

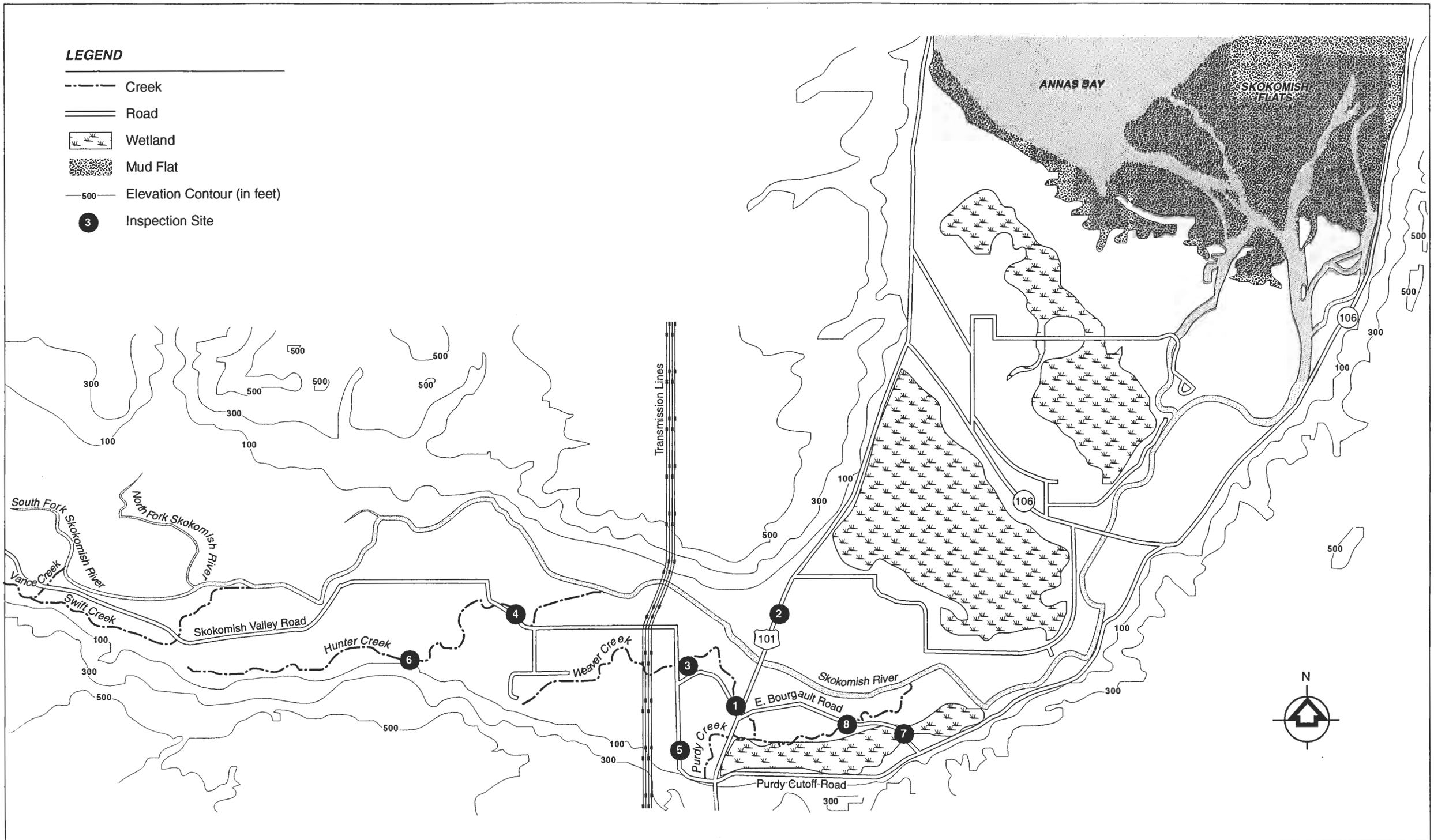
- Site #1 is at the Weaver Creek opening through the US 101 embankment. Concerns at this location related to the size of the openings and the blockage

created during extreme floods by overbank vegetation. Overgrown vegetation at this location restricts flow during flood events.

- Site #2 is at the old, abandoned channel under US 101 to the north of the main Skokomish River channel. Interest was expressed in re-opening the old channel to increase the hydraulic capacity through the US 101 embankment and reduce the impact of the highway on upstream flood levels. This possibility was explored in Issue 1 and included in the recommendations to address Issue 1.
- Site #3 is on Weaver Creek downstream from the Skokomish Valley Road. The debris blockage consists of a beaver dam in the final stage of construction. WDF and the Tribe concurred that removal of this blockage will not damage fish habitat.
- Site #4 is on Hunter Creek upstream from the Skokomish Valley Road. There is a debris dam that could be notched or removed. Access is difficult to this site so the work may have to be done by hand. WDF and the Tribe concurred that removal of this blockage will not damage fish habitat.
- Site #5 is on an unnamed creek leading to the George Adams Salmon Hatchery. The debris blockage consists of a beaver dam. The hatchery manager indicated that this beaver dam was removed twice in 1993 and has been rebuilt.
- Site #6 is on Hunter Creek and abuts private property. A landslide and debris dam has rerouted the creek such that it encroaches on an adjacent tree nursery. The cut bank, which is actively eroding onto the tree nursery, should be stabilized using bioengineering techniques and planted to reduce future exposure to erosion. WDF and the Tribe concurred that this approach to bank stabilization will not damage fish habitat at this location.
- Sites #7 and #8 are on Bourgault Road at a bridge crossings of Purdy and Weaver Creeks, respectively. At both locations, Valley residents noted that flooding has worsened in recent years as evidenced by the increase in the frequency of water passing over the road. There is no evidence of an isolated debris blockage at either site to explain the increase in flood levels. Therefore, no debris removal action is recommended for these sites. However, these locations appear to be affected by other broader-scale river adjustments that could be causing higher water levels throughout the area. As noted in previous chapters, recent surveys of the river channel show considerable sediment deposition in the lower reaches of the Skokomish River.

Fisheries and Riparian Considerations

Each of the maintenance alternatives for the Valley drainage network must be undertaken in a manner that also enhances riparian and fisheries habitat. The creek network of the Skokomish River plays an integral role in the abundance and diversity of aquatic habitat in the system. According to published data on the abundance of fish stocks using the tributary systems of the mainstem (FishPro 1992), tributaries throughout the system serve vital functions for spawning, rearing, and feeding habitat.



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Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 6-12.
CREEK BLOCKAGE INSPECTION SITES

Most of the area through which the tributary systems flow is alluvial (i.e., composed of materials deposited by the Skokomish River). This alluvium represents a rich deposit of tillable soils that has been farmed or pastured by successive generations. Although highly altered, the tributary systems represent a critical part of the biological, hydrologic, and physical interrelationships that compose the riverine and stream ecology of the area.

It is important to understand the functions and values of riparian systems. The riparian system serves as the transition zone between the wetted surface of the stream or river, and the drier upland areas. The aquatic system in the riparian zone has a direct effect on the terrestrial ecosystem. For example, soils in the riparian zone are often saturated to the surface and are inundated during periods of high water and flooding, which gives rise to a great variety of habitats and a vegetation mix that is not duplicated in the terrestrial environment. Upland areas, in turn, greatly influence the shape, size, and composition of the riparian zone by establishing the hydrologic regime and delivering a variety of sediments, organic matter, and food to the riparian ecosytem. Each system has a direct effect on the other, and by altering one component of either system, changes can be seen in both.

Along much of Hunter Creek, Weaver Creek, and unnamed tributaries in the Valley, the existing riparian zone has been degraded and altered by past pasturing and farming practices. Much of the existing riparian zone is a remnant of what was once a valley-wide riparian complex. Despite these changes to the riparian zone, good fisheries stocks remain. Although fish released from three hatcheries located in the Valley may have a negative effect on wild stock, wild stocks have not completely disappeared (FishPro 1992).

Modifications to US 101 Embankment

Analytical conclusions and recommendations relating to this alternative were presented in Issue 3.

Drainage Improvements

Relatively minor overbank or nuisance flooding from the Skokomish River and its tributary creeks is often sufficient to cause road closures and other inconveniences. Local drainage improvements in the Valley would minimize ponding during minor flood events. This could be accomplished with fairly minor effort and expense by providing an exit path from ponded areas to the creek network.

As shown on the air photos in Chapter 4, taken just after the peak flood of 1987, there are many areas where water ponds in the Valley. Some of these ponded areas are caused by the construction of roads in the Valley; others are in natural depressions. The air photos show the remnants of old river meanders across the Valley. These old channels are now local depressions and the locations of ponding. These local depressions can be joined by constructing swales between them and ultimately to one of the creeks in the Valley. This would provide a flow path from low areas to the drainage network and prevent ponding.

Discussions with Valley residents indicate that local ponding is not a major concern, especially in comparison to the impacts of the increased frequency of flooding from the Skokomish River. Nonetheless, improving local drainage for flood hazard purposes would probably have

secondary benefits of increasing the amount of productive land and extending the period when the land is dry enough to farm.

Since drainage improvements on private land would benefit both the public and private property owners, a cost-share maintenance program should be established whereby local property owners could develop onsite surface water drainage systems. Property owners would use the detailed topographic mapping completed for the CFHMP to design the drainage system, submit the mapping and a project description to the County for review, and be responsible for constructing the project. Maintenance project funding under the FCAAP program is a potential source of funding for these types of projects. Therefore, the County may want to consider an application and funding process for these projects that parallels the timing of the FCAAP process.

Floodway Designation for Flood Flow Corridors

Designation of flood flow corridors as floodways is one method by which current open space along critical flood flow pathways could be preserved. A detailed discussion of floodway approaches is presented in Issue 6.

Recommendations

Overbank Vegetation Removal: Overbank vegetation should be selectively removed from Weaver and Purdy Creeks between US 101 and a location approximately 300 feet upstream. WSDOT should complete this maintenance activity at least annually. WDFW should be consulted regarding an ongoing maintenance program at this location to streamline permitting requirements. It is critical that the impact on fisheries and riparian areas be considered prior to implementation of any overbank vegetation removal activities

Debris Blockage Removal: Debris blockages to be targeted for removal were identified at eight locations as part of the 1993 Draft CFHMP. Debris blockages that remain at these locations should be removed. The County should implement an ongoing maintenance program in coordination with WDFW and the Skokomish Tribe to remove blockages that recur at these locations and blockages that develop at other locations. The program should include annual inspections and record-keeping elements. It is critical that the impact on fisheries and riparian areas be considered prior to implementation of any debris blockage removal activities.

Drainage Improvements: The County should implement a program by which local property owners would develop and implement onsite drainage projects. These projects would benefit the public since floodwaters would be conveyed back to the river more rapidly during flood events, reducing the length of time roadways and other public facilities are inundated. Funding should be developed on a cost-share basis between the county and the local property owner. FCAAP maintenance grants should be considered as a potential funding source.

Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Identify and recommend strategies to improve drainage throughout the Valley (action).
- Recommend that all flood control options implemented be monitored for results and that these results be documented (action).

ISSUE 6. REPETITIVE DAMAGES TO STRUCTURES LOCATED IN HIGH HAZARD AREAS

Several structures in the valley are located in the highest hazard areas and receive repetitive damage, resulting in a cycle of damage, disbursement of state and federal funds for repairs, later flooding and damage, and disbursement of funds to repair the same structures. Property acquisition and regulation of land uses are two approaches to breaking this cycle.

Flood hazard analysis and mapping are used as the basis for a variety of decisions in the comprehensive flood hazard management planning process. For the Skokomish River CFHMP, flood hazard mapping was used to identify properties that should be recommended for acquisition and develop a technical basis for regulating land development in the floodplain. The following section describes the methodology and results of the flood hazard analysis. The hazard mapping was then used to develop the following alternatives:

- Acquisition of structures and property located in high hazard areas
- Establishment of mapped regulatory areas corresponding to the high hazard areas where new construction is prohibited and reconstruction is limited to the original footprint of a structure.

While this section describes the hazards that occur in the Valley, it should be understood that differences in hazards are relative. That is, flood hazards exist throughout the lower Skokomish Valley floodplain, and all residents and property in the Valley face some danger. All residents should be aware of the specific hazards they face and respond appropriately.

Analysis Approach and Analytical Conclusions

A five-step process was completed for the hazard analysis. One product resulted from each of the five steps, including the following:

- Map of flood depths for 100-year flood
- Flood hazard database
- Flood hazard map
- Map of recommended acquisitions
- Map of *No-New-Footprint Zones*

Map of Flood Depth

A HEC-2 model of the existing conditions in the valley was developed and used to predict the inundated area and flood depths during a 100-year flood event (see introduction to Chapter 6). Seventeen high-water marks from the December 20, 1994, flood were surveyed by the Mason County Department of Public Works and used for calibration. The estimated flow for this event was 34,500 cfs, 500 cfs less than the discharge estimated by FEMA for the 100-year flood event (FEMA 1988).

The depth of flooding throughout the lower valley was determined using output from the HEC-2 model and detailed mapping of the ground surface topography. Output from the HEC-2 model included water surface elevations (WSEs) at 74 cross-sections along the river. Water surface elevations at each cross-section were input to an INTERPRO workstation using the INROADS software to develop an areal representation of the water surface. The underlying topography was subtracted from the water surface elevations to generate data for the depth of flooding.

An oversized map at a scale of 1 inch = 500 feet was prepared to show the depth of flooding. Depths are shown on the map in 2-foot increments and the map is colored to indicate areas of different flood depths throughout the valley. The map also indicates spot depths shown on a 250-foot grid.

Hazard Database

A database was developed to evaluate the flood hazards at known habitable structures in the Valley. The database was assembled in the steps described below.

A list of all properties within the Skokomish Valley was assembled from county assessor's records. The list contains information, where available, on property owner, address, assessor's identification number, and section-township-range locations. Twenty assessor's maps showing the location and boundaries of each parcel in the list were also obtained from the county. Both resources were used to identify habitable structures and locations. Habitable structures were also identified through field visits and discussions with local residents.

Concurrently, a version of the previously described ground contour map, which showed all of the structures in the valley, was printed. Data in the contour coverage were generated from aerial photos and photogrammetry. Habitable structures shown on this map were cross referenced with the assessor's listing and field information, located by parcel number, and assigned an identification number for the hazard database. A total of 198 habitable structures were identified through this process.

The depth of flooding expected during the 100-year flood was determined for each structure. The corresponding ground elevation at the same location where flood depths were determined was extracted from the topographic coverage using the INROADS software. Both variables were included in the database.

Information was added for structures in the flood hazard database by examining two additional databases related to damage from the December 1994 flood. The first was a listing of

claims submitted to and claims paid by FEMA for property owners having flood insurance. Twenty entries were included in this database.

The second additional database was a listing assembled by the State Department of Emergency Management, the Small Business Administration, and Mason County Emergency Services staff. That database contains descriptions of property damage and dollar estimates of losses. The data are from damage assessment tours by the governmental officials and written reports of losses made by residents. The addresses listed in these databases were additional sources for verification of the structures on the map.

A copy of the database is included with this report as Appendix Z. In the interest of privacy, contents of the columns relating to FEMA claims and flood damages are not included. A copy of the entire database has been forwarded to the Mason County Department of Community Services. Information in the remainder of the database was extracted from the two additional maps described below.

Flood Hazard Map

Two oversized maps showing flood hazards were prepared at a scale of 1 inch = 500 feet for the western and eastern halves of the valley. These maps, titled "Flood Hazard and Recommended Acquisitions" are included as Plates 1 and 2 in the back pocket of this document. The first information put on the flood hazard maps was the flood hazard database identification number for each habitable structure. On the oversized maps, an arrow the point on each structure where the flood depths and ground elevation were determined. Structure locations and identification numbers are not shown on the small-scale maps due to size limitations.

The following information was added to the maps to indicate four corresponding types of flood hazards:

- 100-year flood depths greater than 4 feet: Magnitude and frequency of flooding
- Overbank flow paths: Areas of high velocity
- 200-foot buffer zone established on each of the current riverbanks: Erosion caused by potential changes of river alignment
- Historical flow corridor: Erosion caused by potential changes in river alignment

The areas shown as 100-year flood depths greater than 4 feet correspond to the same areas shown on the previously described flood depth map. Data for overbank flow paths came from KCM's understanding of flood history in the valley and field interviews with County residents.

The corridor formed by the 200-foot buffers was determined by direct measurement on the topographic map.

The historical flow corridor was drawn from a mosaic of air photos taken in approximately 1936. The historical flow corridor includes the river and all gravel bars visible in the photos.

The approximate locations of the existing levees were also included on the maps for informational purposes.

The presence of one or more of the hazards at each of the numbered habitable structures was determined using the completed hazard map. Columns were set up in the database for each type of hazard and an "X" put in the column indicating the presence of the hazard at a structure. Information on the specific flood depth at each structure was also used in the database to segregate structures according to three categories of flood depths: 0 to 0.5 feet, 0.5 to 4.0 feet, and greater than 4.0 feet. These categories were used because 0.5 feet of water generally represents a low hazard and results in minimal damages, while 0.5 to 4.0 feet of water represents a moderate level of hazards and damages. Properties where over 4.0 feet of floodwater occur are designated as high hazard areas since it is difficult to walk or drive at the property and the associated property damages is great. A final step in the development of the hazard database and mapping was to obtain the input of the public during a public meeting held on June 15, 1995.

Of the 198 structures in the database, exact locations were known for 170. Summary statistics were developed after determining hazards for each of the 170 structures:

- Seven, approximately 4 percent, are expected to have less than 0.5 feet of water during the 100-year flood
- 128, or 75 percent, are expected to have between 0.5 and 4 feet of water
- 35, or 21 percent, are expected to have greater than 4 feet of water
- 28 were determined to be located along overbank flowpaths
- 10 were determined to be located within the historic flow corridor or within 200 feet of the existing riverbanks.

The final step in the analysis was to determine which structures should be recommended for acquisition. The recommendations made in this step should be considered preliminary. Owners of some structures recommended for acquisition may not want to sell. Conversely, there may be some structures not identified that residents want added to the list. Perhaps most importantly, inclusion in this database does not indicate that anyone will be forced to sell.

To determine which structures to recommend for acquisition, both the hazard map and the database columns indicating hazards associated with flood depths greater than 4 feet, overbank flow paths, and river corridor were analyzed. Generally, structures with a combination of these factors or with extreme flood depths were recommended for acquisition. Input was also received from Mason County residents and the Mason County Department of Community Services during and after the June 15, 1995, public meeting.

A total of 44 structures are recommended for acquisition, located in the following 8 areas:

- Two near Five Mile Corner
- Eight in the vicinity of the Skokomish Valley Road crossing over Swift Creek and along Eells Hill Road
- Three near the Church

- Two near the Kealy dike
- Five in the vicinity of Weaver Creek and Deyette Road
- Three on the south bank of the Skokomish River near Weaver Creek
- Three along West Bourgalt Road
- One along US 101
- Sixteen along East Bourgalt Road
- One downstream of SR 106.

The general locations of all of the recommended acquisitions are presented on Plates 1 and 2. Specific locations of all structures recommended for acquisition are presented on the oversized Flood Hazard and Recommended Acquisition Map also included in the back pocket of this report.

Following completion of the above analysis, the Skokomish Tribe requested that it be included in the hazard database and recommended acquisition program. Correspondence was received from the Skokomish Tribe on March 20, 1996, providing information to be included in the database (see Appendix AA). A total of 38 structures were recommended for acquisition. These structures were added to the map of flood hazards and recommended acquisitions and the related database.

Map of No-New-Footprint Zones

Following delineation of areas of highest hazards on the hazard and acquisition map, several areas were identified as having relatively higher hazards than other areas in the Valley. More stringent land use regulations are justified for these areas due to these relatively higher hazards. It should be emphasized again that differences in flood hazards in the Skokomish Valley are relative. That is, flood hazards exist throughout the Lower Skokomish Valley floodplain, and all residents and property in the Valley face some danger. The areas identified as higher hazard areas were those where, based on engineering judgment and flood hazard management principles, imminent threats to life and property due to flood hazards exist. New construction should therefore be prohibited in these areas, shown on Figures 6-13a through 6-13d, and described in the following:

- No-New-Footprint Zone 1: This area, located between the Skokomish River and Purdy Creek, is frequently flooded and drains very slowly. Over 4 feet of water is expected to inundate the area during the 100-year flood. Sixteen residential structures are recommended for acquisition in this area. During the CFHMP adoption process many of the residents recommended that is be designated as a no new footprint zone.
- No-New-Footprint Zone 2: This area was delineated based on the corridor formed by 200 foot buffers on either side of the current riverbanks and the historical flow corridor based on 1936 air photos. The boundaries of the area were determined by using that line farther from the river.
- No-New-Footprint Zone 3: This large area is expected to be inundated to depths greater than 8 feet during the 100-year flood event. As discussed in

Issue 3, it is important that this area remain as open as possible to allow floodwaters to be conveyed through the US 101 bridge openings for Weaver and Purdy Creeks.

- No-New-Footprint Zone 4: This area was established based on input received from the Skokomish Tribe (18 March 1995, personal communication). Depths of floodwater expected over most of this area during the 100-year flood are greater than 4 feet. Much of the area is wetland, which serves an important function in storing floodwaters. Preferential flow paths exist in the vicinity of the US 101 and SR 106 embankment openings where there are hazards due to higher velocities.

Recommendations

The County, in coordination with Ecology, should pursue all potential sources of funding for acquisition of the 82 structures recommended for acquisition. As described in Chapter 5, funding sources include the National Flood Mitigation Fund, the State Hazard Mitigation Program, and the State Flood Control Assistance Account Program. Acquisition should occur only if the property owner is willing to relocate outside of the floodplain.

Mason County submitted an application in March 1996 to fund acquisitions in the East Bourgalt Area under the "Fast Track" Hazard Mitigation Grant Program. This "fast track" was set up in response to winter storms of 1995. The application was under review by the State at the time of preparation of this plan.

The County should incorporate the No-New-Footprint Zone map into a flood damage prevention ordinance. Details relating to development of the ordinance are presented under Issue 7.

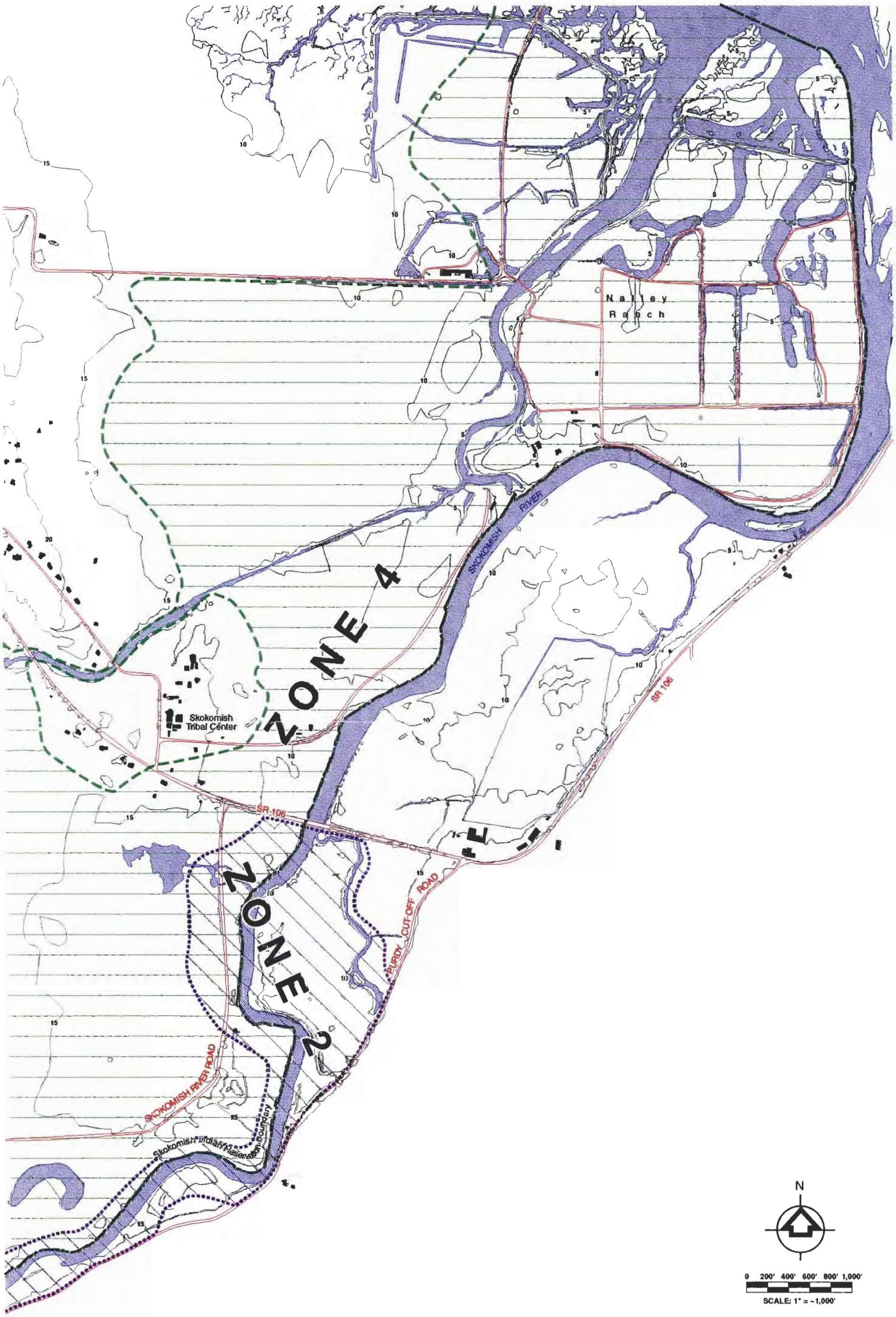
Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions:

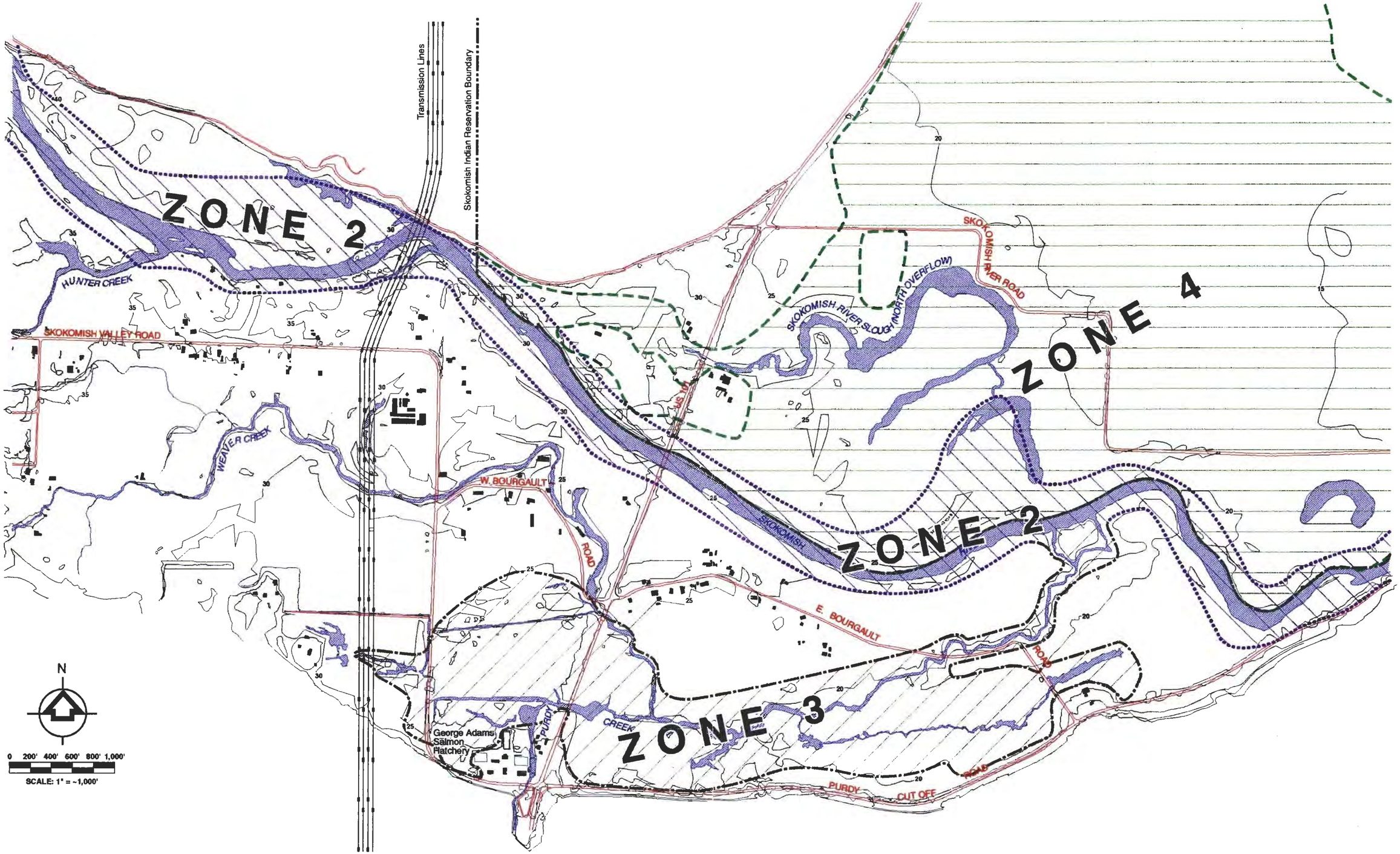
- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Identify areas in the Valley where land buyouts, land swaps, or relocation should be encouraged (action).

ISSUE 7: NEED FOR FLOODPLAIN DEVELOPMENT REGULATIONS

Damage from flood hazards in the Skokomish Valley can be reduced if a program to manage floodplain uses is implemented. The program would allow only development appropriate to the type and magnitude of hazard present in any particular location in the Valley. Such a program is developed through a two-step process. The first step involves analysis of flood hazards, and is typically accomplished using computer models that simulate floodplain



KCM 1917 First Avenue Seattle, Washington 98101	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-13a. "NO-NEW-FOOTPRINT" ZONES— RIVER MOUTH/RESERVATION VICINITY



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Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 6-13b.
"NO-NEW-FOOTPRINT" ZONES—
WEAVER/PURDY CREEK VICINITY

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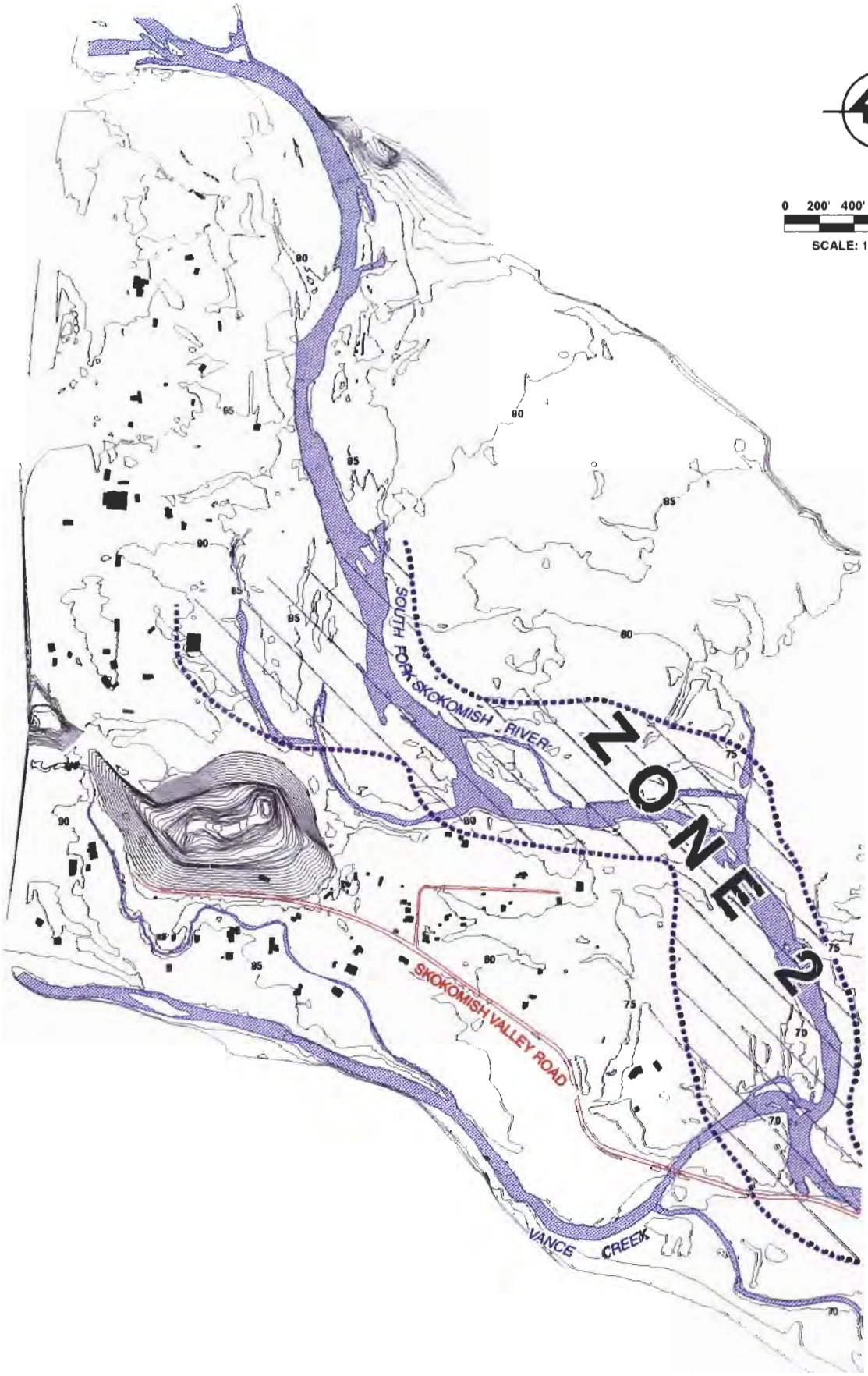
Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 6-13c.
"NO-NEW-FOOTPRINT" ZONES—HUNTER CREEK VICINITY



KCM 1917 First Avenue Seattle, Washington 98101	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-13d. "NO-NEW-FOOTPRINT" ZONES—FIVE MILE CORNER/VANCE CREEK VICINITY

hydraulics. The second step is to translate the results of the hazard analysis into specific regulatory standards that are enacted locally to control where and how development occurs.

The following sections describe the regulatory programs at the state and federal levels that guide development of local flood damage prevention ordinances, and the specific hydraulic analysis procedures followed to analyze flood hazards in the Skokomish Valley. Three alternative regulatory approaches to floodplain regulation are presented. Together with the corresponding mapping and criteria that were developed for each approach and the previously presented valley-wide hazard analysis, these approaches represent the foundation upon which a floodplain management program for the lower Skokomish Valley should be developed.

Regulatory Background

Local, state and federal agencies commonly separate floodplains into floodways and flood fringe areas to denote areas of higher and lower flood hazards. Floodways are areas reserved to convey the waters of the 100-year flood. Flood fringe areas are areas that can be completely obstructed without increasing water surface elevations in the floodway by more than a designated amount. FEMA currently requires that the boundary of these areas be located such that a maximum rise in water surface elevations of one foot would occur in the floodway if the entire flood fringe were to be filled.

Once the location of the floodway and flood fringe are determined, FEMA and Ecology require that a local flood damage prevention ordinance be adopted to regulate development in these areas. More stringent regulations are required for floodways than flood fringe areas due to the greater hazards associated with floodways, including high velocities, high erosion potential, and the transport of large woody debris and sediment. Therefore, encroachments including fill, new construction, substantial improvements, and other development is prohibited in floodways unless a registered engineer or architect can demonstrate that these activities will not result in any increase in water surface elevations during the 100-year flood.

The local flood damage prevention ordinance may contain some allowances for construction or reconstruction of residential structures within designated floodways. These allowances are for activities that are not defined as substantial improvements, including the following:

- Repairs, construction, or improvements to a structure that do not increase the ground floor area
- Repairs or improvements to a structure that do not cost more than 50 percent of the market value of the structure either before the repair or reconstruction is started, or, if the structure has been damaged and is being restored, before the damage occurred.

Work done on structures to comply with existing health, sanitary, or safety codes or to structures identified through local, state, or federal historic preservation programs are not restricted by the 50 percent threshold for allowable repairs.

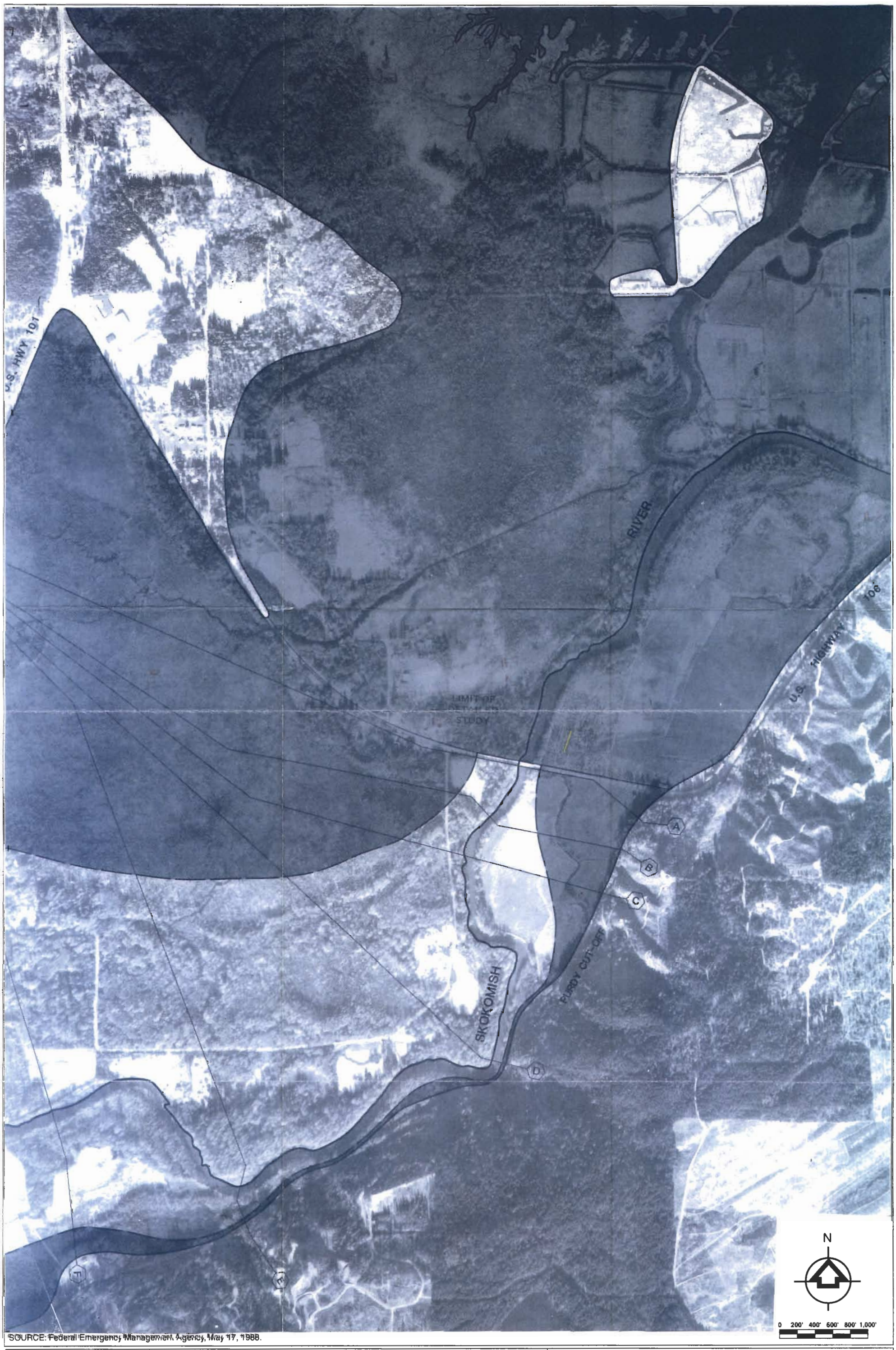
Development is allowed in flood fringe areas if the following standards are followed:

- New construction and substantial improvements are to be anchored to prevent flotation, collapse, or lateral movement. Special anchoring methods are required for manufactured homes
- Construction materials, methods, and practices that minimize flood damages should be used. Electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities should be designed, and located or elevated, to prevent water entry and accumulation
- Water supply, sanitary sewage and onsite waste disposal systems are to be designed and located so that damages to and discharges from these systems do not occur during flooding
- New construction or substantial improvement of any residential structure is required to have the lowest floor, including the basement, elevated to or above the water level resulting from the 100-year flood (the base flood elevation)
- Fully enclosed areas below the lowest floor that are subject to flooding are prohibited, or shall be designed to automatically equalize flood forces on exterior walls by allowing for the entry and exit of floodwaters through openings in the structure
- Two options are possible for new construction or substantial improvement of any commercial, industrial, or other non-residential structure. The first is to elevate the lowest floor, including the basement, to or above the water level resulting from the 100-year flood. The second option is to floodproof the structure so that all areas below an elevation one foot above the base flood elevation are watertight
- New or substantially improved manufactured homes must be elevated on a permanent foundation such that the lowest floor is elevated to or above the base flood elevation.

A Flood Boundary and Floodway Map was issued by FEMA in May 1988 for portions of the Skokomish River (see Figures 6-14a through 6-14c). As noted on the floodway map, much of the Skokomish River valley was designated by FEMA to be a floodway. As described above, development restrictions for floodways mean that activities such as new construction or substantial improvements would not be allowed in much of the Valley.

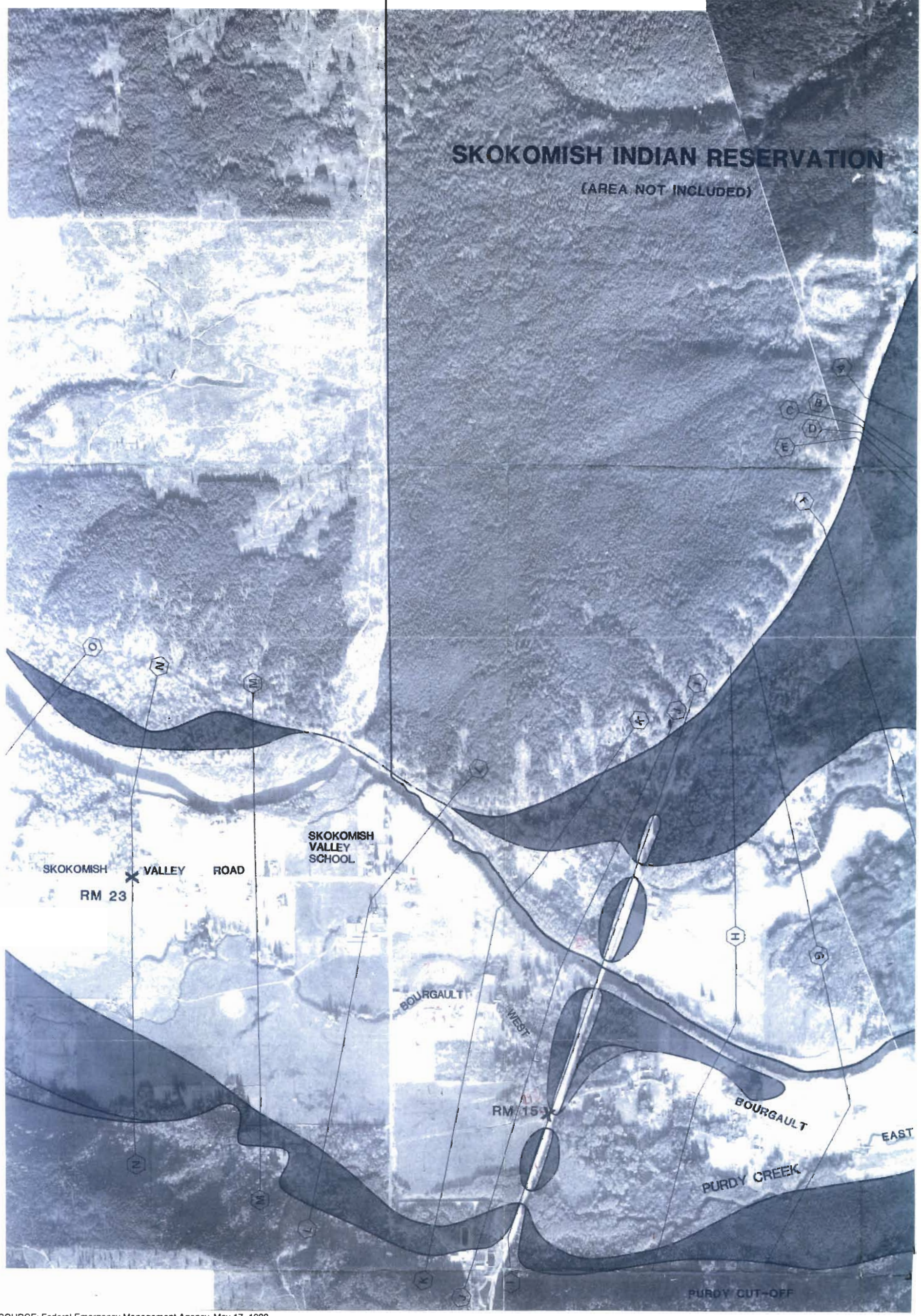
The County has negotiated an agreement with FEMA to reconsider the floodway delineation in the Valley and possibly propose an alternative floodplain management approach. The goal of an alternative approach would be to develop a floodplain management policy that allows some development by residents of the Valley while still providing sufficient open areas for passage of floodwaters.

As part of the agreements during this period, the County adopted a Flood Damage Prevention Ordinance in 1991. The ordinance contains interim regulations for special flood risk zones. A copy of the ordinance is included with this report as Appendix BB.



SOURCE: Federal Emergency Management Agency, May 17, 1988.

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-14a. FEMA FLOODWAY MAP— RIVER MOUTH/RESERVATION VICINITY



SOURCE: Federal Emergency Management Agency, May 17, 1988.

KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-14b. FEMA FLOODWAY MAP— PURDY CREEK VICINITY

SOURCE: Federal Emergency Management Agency, May 17, 1988.

KEY TO MAP

500-Year Flood Boundary
100-Year Flood Boundary
FLOODWAY FRINGE
100-Year Flood Boundary
500-Year Flood Boundary
Approximate 100-Year Flood Boundary
Cross Section Line
Elevation Reference Mark
River Mile

FLOODWAY

A — A

RM7

• M1.5

NOTES TO USER

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the Federal Emergency Management Agency.

This map is intended for use in defining floodway and flood boundaries. Zone and Base Flood Elevation (BFE) data may not be correct as shown. Refer to the separately printed Flood Insurance Rate Map for correct Zone and BFE data.

Refer to the Flood Insurance Rate Map for description of Elevation Reference Marks.

This map does not show all flood boundaries. Refer to the Flood Insurance Rate Map for additional flood boundaries.

For adjoining map panels, see separately printed Index To Map Panels.

APPROXIMATE SCALE IN FEET

1000 0 1000

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Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 6-14c.
FEMA FLOODWAY MAP—
VICINITY OF NORTH/SOUTH FORK CONFLUENCE

Alternatives, Analysis Approach, and Analytical Conclusions

Three different alternatives and analytical methods were used to evaluate the hydraulic effects of development in the Skokomish River Valley:

- Conventional floodway
- Split floodway
- Density floodway.

All three of these methods involve use of the HEC-2 hydraulic model. The first two methods (conventional and split floodway) used the model to simulate the 100-year flood under existing land conditions. The existing conditions model was altered to determine the location of the floodway, run again, and the output analyzed and mapped. The third method (density floodway) involved a spreadsheet analysis of output from the existing conditions model and the method described in the *Hydraulic Methods for Evaluating Density Floodways* (COE 1981).

The conventional floodway and density floodway analysis were completed for the reach of the floodplain between the confluence of the North and South Forks and SR 106. This is the same reach analyzed for the 1988 FEMA Flood Insurance Study. The split floodway analysis was completed for the reach between the Skokomish Valley Road bridge over Swift Creek and US 101. This reach was chosen because of the topography in that portion of the Valley.

Conventional Floodway

The conventional floodway analysis is the most common method used to delineate the boundary between the floodway and the flood fringe. This approach involves a series of simulations of encroachments on the central portion of the floodplain where the river is located. An increase in water surface elevations in and adjacent to the river results as the encroachments move toward the river. The encroachments are increased until a targeted increase in water surface elevations in and adjacent to the river is achieved. The resulting limits of the encroachment describe the limits of the floodway.

The targeted increase in water surface elevation used for the Skokomish River floodway analyses was 0.5 feet. This criterion was used because it forms the basis of a 1989 agreement between Mason County and Ecology. In addition, it provides a more conservative level of protection than the 1-foot rise allowed by FEMA.

The goal of the conventional floodway analysis was to achieve as close to a 0.5-foot rise as possible at all cross-sections. This is accomplished using the floodway analysis option contained in the HEC-2 model. In the completed conventional floodway model, 38 of the 48 cross-sections analyzed were within 0.05 feet of the 0.5-foot rise goal. The location of the flood fringe/floodway boundary based on the conventional analysis is presented in Figure 6-15.

Split Floodway

The split floodway approach, like the conventional floodway approach, maximizes the developable area based on a maximum 0.5-foot rise in the floodway. However, while the conventional floodway involves maintaining conveyance in a corridor consisting of the river channel and land directly adjacent to it, the split floodway involves maintenance of two

separate conveyance corridors in the floodplain. The result is that development is allowed in an island within the floodplain.

A recent publication by FEMA summarized the history and agency acceptance of the split floodway approach (Cook 1995). The split floodway concept was adopted for use several years after floodway regulations were generally accepted. Though it initially met with some resistance from FEMA, the COE, and other engineering staff, it was applied in a limited number of cases and has now become a frequently accepted method of floodway location.

The split floodway approach analyzed in the lower Skokomish floodplain between US 101 and the Skokomish Valley Road bridge over Swift Creek because of the topography in this portion of the Valley. Ground elevations are relatively higher along the Skokomish Valley Road, with lower elevations along the south valley walls. The initial scenario tested was based on establishment of a developable island with boundaries based on the higher ground in this area. Therefore, the northern floodway included the main river channel, while the southern floodway was defined by areas of low elevation in the southern portion of the Valley.

An initial simulation to determine the resulting water surface elevations indicated that the water surface elevation in the two floodways was greater than the allowable 0.5 feet at some cross-sections. Therefore, the width of the island was decreased at several sections to produce a greater conveyance area. The width of the island was successively altered until the water surface elevations in both of the floodways was no greater than 0.5 feet at all cross-sections.

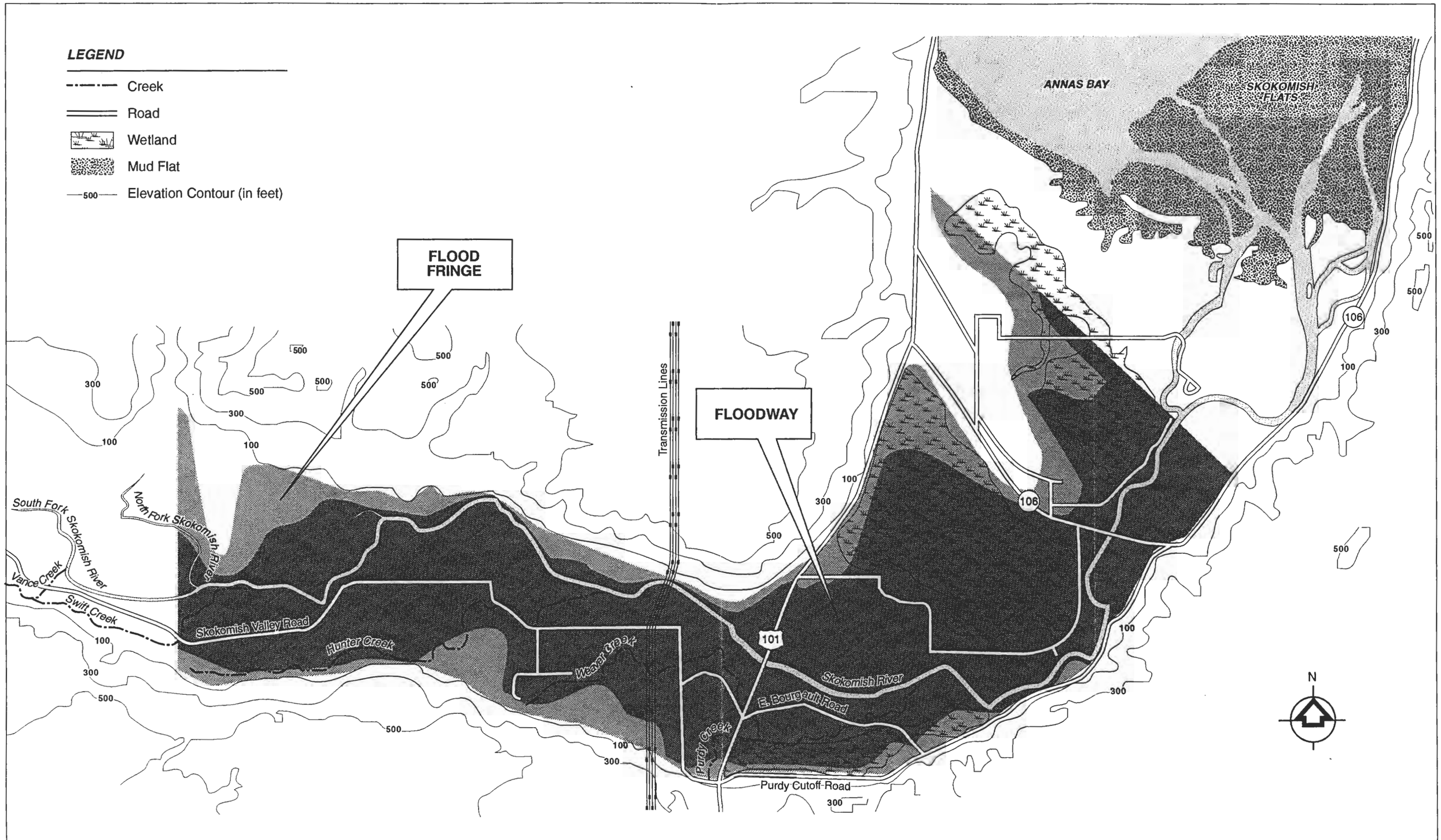
The locations of the floodways and the developable island are shown on Figure 6-16. The island where development would be allowed under this scenario is approximately 3.3 miles long and, on average, approximately 700 feet wide. The area is approximately 244 acres.

Density Floodway

While not commonly used by FEMA, the density floodway approach is an alternative to conventional floodway analysis. Under this approach, no distinction is made between floodway and flood fringe. The effect of development on floodplain hydraulics is controlled by limiting the allowable percent development on a parcel-by-parcel basis throughout the floodplain. These, and other related development criteria produced from the analysis, are then integrated into the flood damage prevention ordinance. During the municipal review process for new construction or substantial improvements, development proposals are evaluated based on these criteria regardless of location in the floodplain.

The density floodway approach is used in situations where the flood hazard, including both depth and velocity, is generally constant across the floodplain. This is the case in floodplains where the following conditions exist:

- The cross-section of the channel is small compared to the cross-section of the floodplain; in other words, a relatively small portion of the total conveyance through the floodplain is provided by the channel
- Conveyance throughout the floodplain is relatively uniform
- Overbank flood depths are shallow and uniform
- Overbank velocities are low and uniform.



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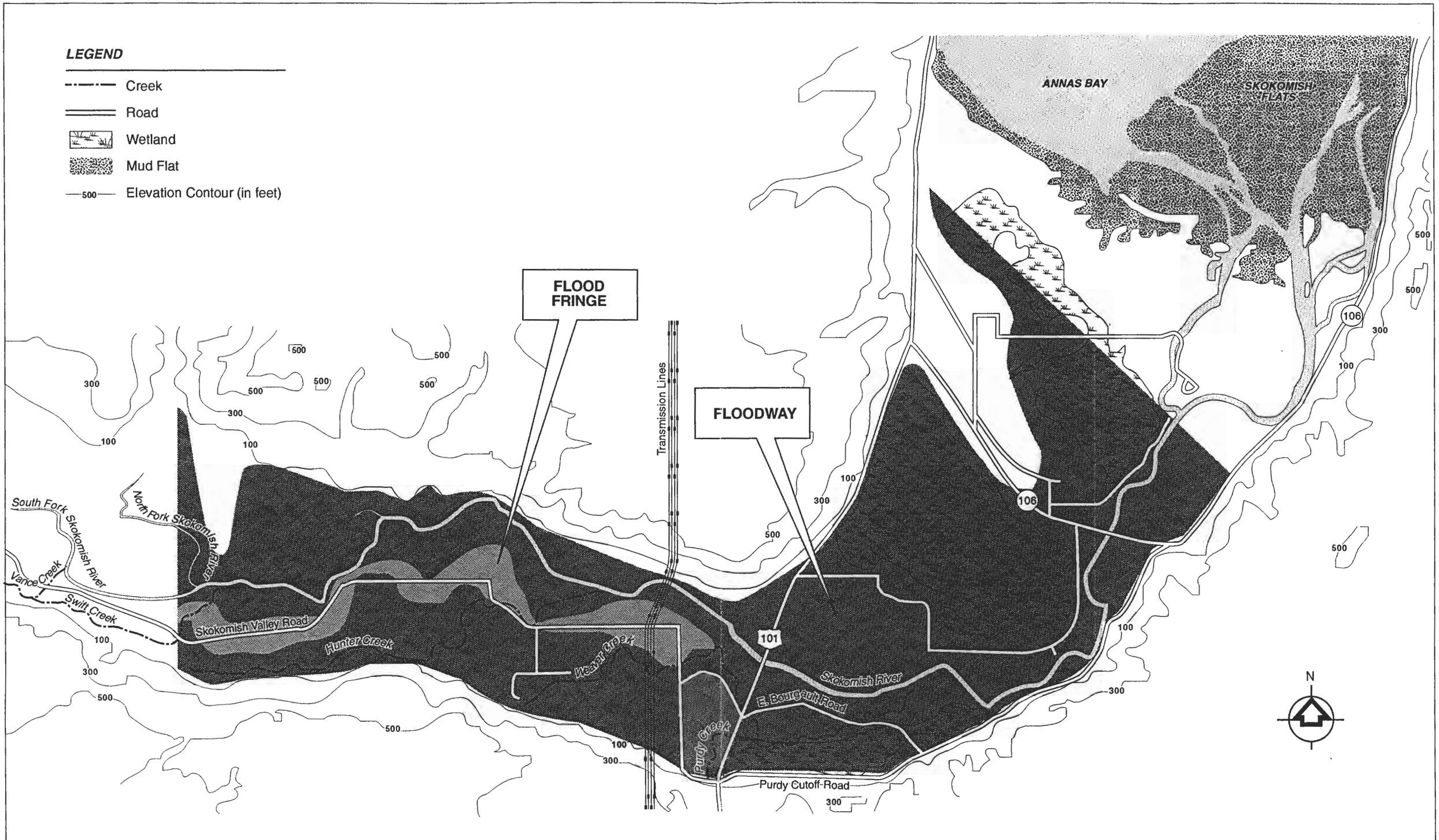
Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 6-15.
CONVENTIONAL FLOODWAY



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Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD
HAZARD MANAGEMENT PLAN

Figure 6-16.
SPLIT FLOODWAY

In floodplains where overbank flood depths or overbank velocities are large, it may still be possible to use the density approach. The main consideration is that the product of these variables should be constant. If the product of these variables is generally constant along the floodplain, it is appropriate to assume that the hazard level is also generally constant.

When the flood hazard is relatively constant throughout the floodplain, it would be neither technically appropriate nor equitable to property owners to limit development in one area while allowing it in another. Therefore, the conventional floodway analysis and regulatory approach should not be used. Under the density floodway approach, the burden of development limitations is distributed equitably to all residents of the floodplain since they face a similar level of flood hazard. However, use of the approach would allow for land development and related economic benefits for all owners of property meeting the criteria, regardless of location in the floodplain.

Experience in Other Communities

The City of Richland and Snohomish County have adopted flood damage prevention ordinances based on the density approach. The City of Richland's ordinance regulates development along the Yakima River, and Snohomish County's along the lower Stillaguamish and Snohomish Rivers. They both place restrictions on the percentage of parcel areas that can be developed and the percentage of the cross-section perpendicular to flow that can be obstructed. The actual values of these variables differ.

City of Richland provisions for floodplain regulation under the density approach are included in the city zoning code. A separate zone, called a Floodplain Combining District, or F-district is shown on the zoning map and designed to apply to all areas of special flood hazards. The combining district designation has been called an overlay zone in other municipalities. It is designed to be coincident with other zones set up to regulate a range of land uses. Therefore, where the F-district occurs, density criteria must be met in addition to provisions of the underlying zone.

The general standards presented in the ordinance for the zone include the density criteria as well as requirements relating to location and secondary drainage channels:

- Location: All new construction and substantial improvements must be located on the highest ground possible
- Maximum allowable density: New construction and substantial improvements cannot exceed 10 percent of the total area of any lot in a floodplain, agriculture, or public reserve district, and cannot exceed 50 percent of the total area of any lot in a general business or commercial recreation district
- Maximum allowable obstruction: In floodplain, agriculture, and public reserve districts, no new construction or substantial improvements, including filling associated with new construction and existing development, can exceed a maximum allowable obstruction of 33 percent. The obstruction is further limited to a maximum of 200 feet per 5-acre lot

  The maximum allowable obstruction is specifically determined as

33 percent of a line within the lot lines of the subject lot when drawn along the shortest distance from the midpoint of the river channel through the midpoint of the lot when drawn perpendicular to known floodwater patterns within the lot lines of the subject lot (Richland 1983)

- Secondary drainage channels: Natural drainage channels that convey floodwaters and are secondary to the river channel are set aside as open space or maintained for open space uses. These channels are shown on a series of maps attached to the zoning code. If this provision precludes new construction or substantial improvements, alternative development designs, such as post-and-pile foundations, are required to be used
- Orientation: All new construction and substantial improvements must be oriented parallel to known floodwater patterns.

Snohomish County provisions for floodplain regulation under the density approach are included in the County Flood Hazard Ordinance. The majority of the land regulated using the approach is prime agricultural land that has been farmed for many years, and the County sought to preserve existing agricultural land uses. The density approach was a mechanism to achieve this goal and the goals of protecting public health, safety, and welfare, and minimizing flood damage.

A maximum development criterion of 2 percent was selected to achieve these goals, based on a review of hydraulic parameters and the desire to maintain a conservative level of development. This criterion allows development of two acres for agricultural facilities on the typical 100-acre farm in the area. The ordinance also requires the following:

- The maximum obstruction allowed on any given parcel cannot exceed 15 percent of any line drawn across the property and perpendicular to flood water flow
- Natural drainage channels must be preserved
- All development must be oriented parallel to the floodwater flow direction.

Hydraulic Analysis

Hydraulic analysis was completed to develop criteria for establishment of a density floodway for the Skokomish Valley. The procedure is described in *Hydraulic Methods for Evaluating Density Floodways* (COE 1981). The analysis, based on a 0.5-foot rise in flood elevations, included the following steps:

- Output was compiled from the HEC-2 model used to simulate the 100-year flood under existing land use conditions
- Hydraulic data were extracted from the HEC-2 output, and additional data were calculated based on model output. The data were then tabulated for Sections 13 through 54 of the model, covering the reach from SR 106 to the confluence of the North and South Forks. Tabulated data included the following:
  - Channel width

  - Cross-sectional width of the inundated overbank area
  - Overbank cross-sectional area inundated
  - Overbank discharge
  - Average overbank velocity
  - Hydraulic depth
  - Slope of the energy grade line
  - Manning's roughness for the overbank areas
- Averages and standard deviations were calculated for the hydraulic depths, slope of the energy grade line, and average overbank velocity
- The suitability of the floodplain for the density floodway approach was evaluated
- Maximum hydraulic depth and maximum slope of the energy grade line were used in a graphical analysis to determine the allowable percentage development
- Data for allowable percentage development were used to calculate the following density criteria:
  - Maximum allowable width of structure parallel and perpendicular to flow (assuming a square structure)
  - Minimum allowable space between structures parallel and perpendicular to flow (assuming square structures)
  - Maximum allowable flow blockage (maximum allowable obstruction).

The procedure was completed for the entire river reach and for portions of the river reach where hydraulic characteristics were similar in a series of adjacent cross-sections. Abridged tabulations of data for all the river reaches are presented in Appendix CC. The maximum percentage allowable development for the entire river reach was calculated as the average of the allowable development determined for all smaller segments. This approach was used to minimize the effect any one cross-section had on the results.

Results

The results are presented in Figure 6-17 and include the following:

- The maximum allowable percentage development is 3 percent. For example, for a minimum lot size of 5 acres, the maximum building footprint allowed is 6,534 square feet
- The maximum allowable width of a structure parallel and perpendicular to flow is 80 feet
- The sum total of all the structures footprint shall not exceed 6,534 square feet in a 5-acre area or to FEMA standards in this adoption and is open for further review
- The maximum blockage allowed is 17 percent.

Comparison of Alternative Approaches

There are similarities and differences in the regulations that would result from the three different approaches to floodway regulation presented above. The summary presented in Table 6-18 illustrates how well each of the alternatives meets a range of floodplain management objectives. The following is a brief summary of the locations where development would be allowed and the total acreage included for each alternative:

- Conventional floodway: Development would be allowed in flood fringe areas on either side of the river, with a total area of approximately 355 acres
- Split floodway: Development would be allowed in an island between two floodways. The island would be located on the high ground along the valley, with a total area of 244 acres
- Density floodway: Development would be allowed throughout the floodplain, with the possible exception of the areas of highest flood hazards. Given a total floodplain area of approximately 1,600 acres and the 3 percent allowable development, a total area of 48 acres could be filled or covered by buildings.

The following assumptions made in calculating the developable acreages should be kept in mind when comparing the alternatives:

- Preservation of open space and isolated high hazard areas within flood-fringe areas outside the conventional and split floodways is not included
- It is unlikely that all the area within the flood fringe and the developable island would be completely filled under the conventional and split floodway approaches. If it is assumed that approximately 15 percent of each 5-acre lot was either filled or covered by a structure, the total area that would actually become filled or covered would be approximately 52 acres for the conventional approach and 36 for the split floodway
- Parcels where development has already taken place are included in the above estimates. Since most of the development has taken place along the Skokomish Valley Road and the conventional and split floodway approaches treat this area quite differently, there would be a differential reduction in the amount of new development allowed under the three alternatives.

Regardless of the type of floodway adopted, FEMA regulations would still require that standards such as elevation of the lowest floor to or above the base flood elevation and floodproofing techniques be applied to all new construction or substantial improvement.

The impact of each alternative on other flood hazard management options that may be considered would vary. An alternative might preclude construction of certain structures, depending on the amount of rise in floodway water surface elevations that would result.

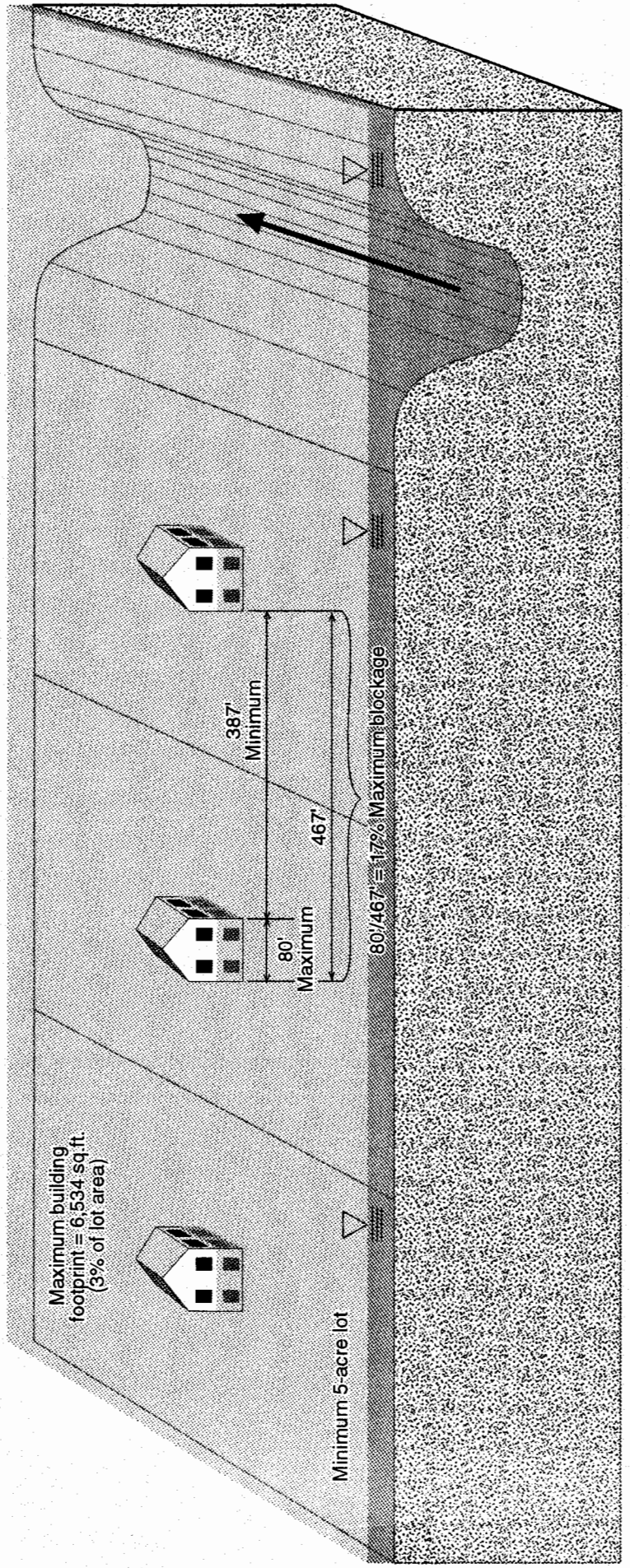

Figure 6-17.
DEVELOPMENT CRITERIA BASED ON DENSITY
FLOODWAY ANALYSIS

Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD
MANAGEMENT PLAN

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TABLE 6-18.
SUMMARY OF FLOODWAY ALTERNATIVES

	Ability of Floodway Concept to Achieve Objective		
Objective	Conventional Floodway	Split Floodway	Density Criteria
Preservation of high-hazard areas as open space	Low - high hazard areas outside floodways can be developed	Moderate - development directed to *relatively* lower hazard areas	Moderate - if high hazard areas such as secondary flow channels preserved in addition to density criteria
Equitability of regulations	Low - property owners facing similar hazards regulated according to different standards	Moderate - improvement over conventional floodway due to limitations in highest hazard areas	High - All property owners in the valley face flood hazards, all would share burden of flood hazard management regulations
Preservation of adequate conveyance	High - Hydraulic calculations indicate that conveyance of 100 year flood could be achieved with up to 0.5 foot rise in floodway	High - Hydraulic calculations indicate that conveyance of 100 year flood could be achieved with up to 0.5 foot rise in floodway	High - Hydraulic calculations indicate that conveyance of 100 year flood could be achieved with up to 0.5 foot rise in floodway, which is coincident with floodplain
Regulatory effort required	Moderate - would require preparation of flood hazard management ordinance, new flood insurance rate map, and additional step in site and subdivision review process	Moderate - would require preparation of flood hazard management ordinance, new flood insurance rate map, and additional step in site and subdivision review process	Moderate - would require preparation of flood hazard management ordinance, new flood insurance rate map, and additional step in site and subdivision review process.
Enforcement effort required	Moderate - to obtain complete compliance, inspections would take place during and after construction or improvement	Moderate - to obtain complete compliance, inspections would take place during and after construction or improvement	Moderate - to obtain complete compliance, inspections would take place during and after construction or improvement

Recommended Actions

The County should adopt a flood damage prevention ordinance and Flood Insurance Rate Map based on the density floodway approach. The Planning Advisory Committee is in agreement that it is the best approach for the Valley (September 14, 1995 meeting). It is the most equitable of the three approaches analyzed, allowing for a limited amount of development in the Valley while meeting the hydraulic criteria. The ordinance should also incorporate provisions to ensure that no new construction occurs in the high hazard areas and redevelopment occurs only if the area of the new footprint is equal to or less than the old footprint of the structure (see issue 6). In order to adopt the ordinance, the county should follow its process for development

and adoption of regulations. The County will also need to coordinate with FEMA to have the ordinance approved.

A draft Flood Damage Prevention Ordinance based on the density floodway is included with this report as Appendix DD. The draft was developed based on the model ordinance for Washington State (Ecology 1988), FEMA requirements outlined in *Guide for Ordinance Development - Community Assistance Series* (FEMA 1978), and ordinances from the City of Richland and Snohomish County. Since this ordinance is based on state and federal requirements, few revisions will likely be required before the adoption process can begin.

The County should initiate a process of map revision with FEMA in accordance with CFR Title 44, Chapter 1, Part 65. Revisions are allowed based on use of better data, including better hydraulic and topographic data, and use of an alternative methodology (FEMA 1990). Once FEMA is contacted regarding the revision request, a preliminary review of the request and associated data will be conducted. If all the necessary supporting data have been provided, FEMA will send an acknowledgment letter indicating the amount of time needed to complete a detailed review of the request and supporting data (usually 90 days). If changes are warranted, FEMA will either physically revise the current effective map or issue a Letter of Map Revision (LOMR). A revision made through the physical map revision process does not become effective until the map has been issued in preliminary form, has passed through the appropriate review periods, and is printed and distributed.

A letter to Mason County from FEMA providing further guidance on submission requirements is included as Appendix MM. The letter indicates that FEMA has "agreed in concept" to the Density Floodway.

Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Remain eligible for all the benefits and assistance available through the Federal Emergency Management Agency (FEMA) by adopting a floodplain map and Comprehensive Plan that meet FEMA's requirements for flood hazard management (objective).

ISSUE 8: ENGINEERING STANDARDS AND REGULATORY COMPLIANCE FOR LEVEES

Background

The June 1993 Draft CFHMP documented that sediment deposition in the channel has reduced the flow capacity of the river corridor. This has many causes, both natural and human-induced. Even under undisturbed conditions in the watershed, the lower river is a natural deposition

area. However, human activities have accelerated deposition processes beyond naturally occurring rates.

The Planning Advisory Committee for this CFHMP supports recommendations for watershed restoration, but also recognizes that the effects of these activities will probably not be seen in the lower valley for many years. Therefore, the PAC recommended consideration of interim measures that could be put in place immediately. One of these measures is a low-level set back berm. This alternative had been discussed for some time but had not been investigated using a rigorous engineering approach as part of any comprehensive flood hazard management plan for the river.

During its March 30, 1995, meeting, the PAC unanimously recommended that the alternative of a low-level set-back berm be investigated and considered in the Final CFHMP. The rationale for considering a low-level berm was to contain flows in the river corridor as they were in the past. Therefore, a low-level berm for a relatively low return period, such as a 5-year flood, was to be considered.

In selecting a low return period flood for the berm height, the PAC recognized that most of the Valley bottom is floodplain and is inundated during extreme floods. Therefore, the PAC did not recommend high levees to prevent Valley flooding during extreme floods. For flows greater than a 5-year flood, the berm would overflow and the area outside of the low-level berms would be flooded.

Throughout the period of development and analysis of the low-level berm alternative, discussion also focused on potential alternatives dealing with the existing levee system in the valley. The following sections provide a detailed discussion of both the new low-level berms and the existing levee system.

Public Input

Residents have been particularly outspoken on the issue of diking in the Valley. In particular, two petitions from opposing points of view were prepared by Valley residents. One petition, signed by approximately 130 Skokomish Valley residents and forwarded to the County on March 13, 1995 (included with this report in Appendix EE), states that

> most residents are aware that dikes have been used in many areas in the U.S.A. including the Skokomish Basin. There are pro's and con's on the usage of these structures and the benefits that they do or do not provide. While they may provide protection for those people that live behind these structures, their impacts to land and people upstream and downstream are very real.
>
> In the past the construction of these structures in the Skokomish Valley was done usually with the existing materials provided by the river, woody debris and river rock with some cable. Nature and time work together on these structures. Wood rots out leaving gaps or pockets for erosion to get a foot hold, velocity of the water, changes in stream all have adverse impacts on dikes. The ability for dikes to provide protection decreases as the river bed rises. The rising of the river bed becomes more of a problem as ground water rises behind the dikes causing more impact to the surrounding land.

> When a flood event does occur and the dike is breached or opened up for whatever reasons it is often impossible to close up. At this stage usually all one can do is stand helplessly and watch or run.
>
> The time for a decision has come for Skokomish Residents to say yes or no to this approach to flood prevention. Are these structures what "all" people in the basin want to have and maintain?
>
> Please sign the petition below if you feel diking is not the answer to the flooding problem.

Another petition, signed by approximately 190 Skokomish Valley residents and presented to the PAC during a meeting on September 14, 1995 (included with this report in Appendix EE), supports most structural approaches to flood hazard management, including construction of agricultural dikes:

> We support the maintenance, improvement and construction of Agricultural dikes. The problem is not the agricultural dikes but the build-up of gravel in the river bed.
>
> > The Agricultural Community believes that the river bed is rising in elevation and the quantity of out-of-bank flooding is increasing. This out-of-bank flooding brings the valley residences flooding and unwanted debris. If the bed of the river cannot be lowered, to protect the farmers from unwanted debris the banks of the river need to be raised at certain points. In the past Agricultural dikes have performed the function of keeping flood waters and debris away from areas where they were not wanted.
>
> Agricultural dikes have at least two beneficial functions:
>
> > First - Agricultural dikes will keep debris from the farmer's fields.
> >
> > Second - Agricultural dikes create quiet water on the river side of the agricultural dikes. Quiet water keeps the erosive forces of the flood waters away from river banks. A well placed agricultural dike can protect an unprotected river bank from erosion and damage.
>
> To preserve the economics of agriculture in the valley, agricultural dikes and gravel removal must remain viable tools for River Management. If the river bed is lowered the need for diking is reduced.

Existing Levees

Over the years, residents of the Valley have constructed sections of the levee system to protect their properties during flooding. The approximate locations of the current (1996) levee system are shown on Figures 6-18a through 6-18c.

Sometime during the summer and fall of 1987, an extensive addition was made to the system of levees in place at the time (Trial Brief No 88-2-01971-9, Superior Court for the State of

Washington for the County of Thurston). The levee was constructed of soils bulldozed from the surrounding property.

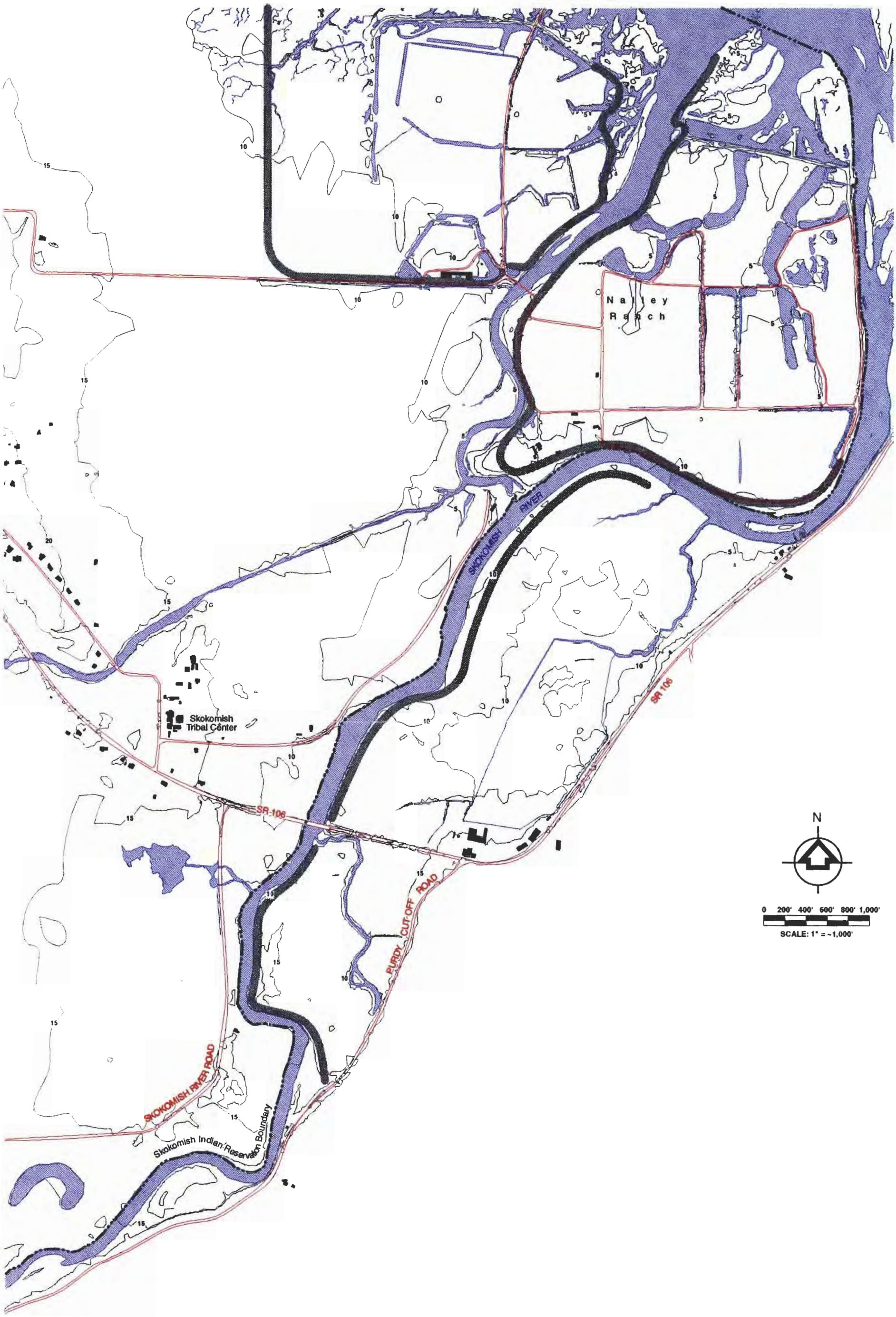
A geotechnical investigation of the existing levees, including the "Church Dike," was completed in August, 1989. The investigation included an evaluation of the material types and engineering properties and the foundation of the levee:

> The foundation soils in the area of the levee are fluvial sediments of recent origin. The surficial three to five feet are generally fine sands and silts with occasional lenses of gravel and would be easily eroded by hydraulic action. The groundwater table is expected to be very close to the level of the Skokomish River.
>
> The materials used to construct the levee appear to have been borrowed from areas immediately adjacent to the levee. The gradational analyses that were completed indicate that the levee fill is very similar to the soils in the top two to three feet of the foundation. The densities noted during the logging of the test pits were similar for both the fill and the in-situ soils [indicating no compaction]
>
> The existing levee varies in height from three to ten feet, in crest width from zero to twelve feet, and in side slopes from 1:1 to 3:1.
>
> The one section of the levee that differs significantly from this assessment is a section of levee just upstream of the Keeley property. In this area, the levee is constructed from sand and gravel and appears to have been end-dumped in place (Klohn Leonoff, 1989).

These results suggest that the current levee was not built according to generally accepted engineering practices and is therefore not suitable for long-term flood protection. This must be considered in developing any alternative involving the current structures.

In many locations the levees are set back from the river with a forested or vegetative buffer between the river and the levee. One exception is the levee along the south bank of the Skokomish River at a sharp bend in the river near the Skokomish Community Church—part of what is called the Church Dike. The levee at this location was constructed directly on the river bank in the right of way for the County Road. This approximately 700-foot long section of levee was intended to discourage the river from changing course and flowing to the south side of the Valley.

A sudden migration of the main channel during a flood could cause loss of life, extensive damage to existing property and roads, require reconstruction of bridges on US 101 to accommodate the new channel location, and damage or destroy all three fish hatcheries located on the south side of the Valley. The consequences of a shift of the main channel of the Skokomish River to the south side of the Valley would clearly be catastrophic. Alternative ways to discourage a channel change at the sharp bend near the Church should be assessed as part of the recommended reconnaissance analysis of existing dikes, proposed bank stabilization projects, and planning for relocation of high-hazard structures and restoration of channel capacity.



KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-18a. CURRENT LEVEE LOCATIONS— RIVER MOUTH/RESERVATION VICINITY

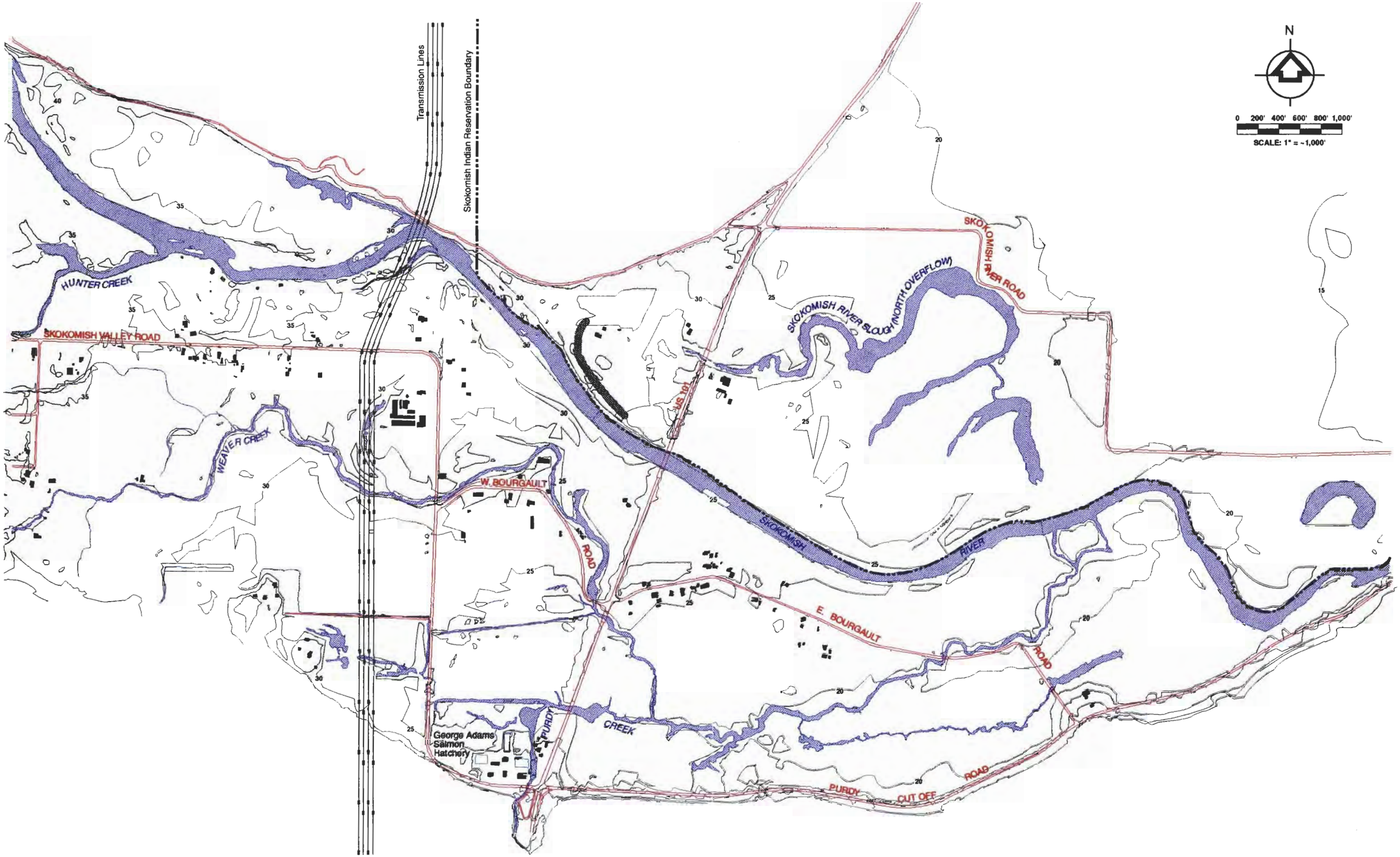


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Figure 6-18b.
CURRENT LEVEE LOCATIONS—
WEAVER/PURDY CREEK VICINITY

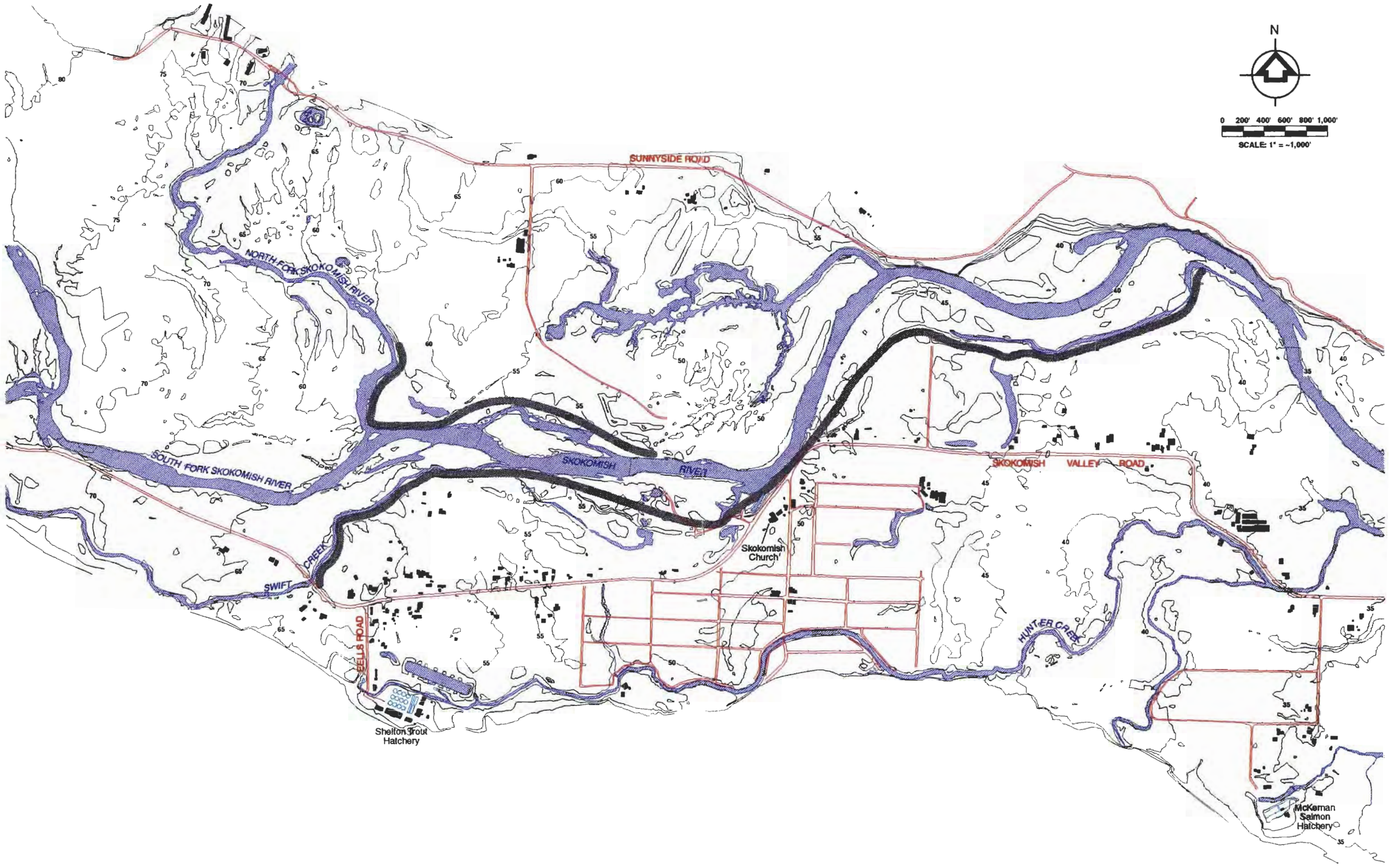

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Figure 6-18c.
CURRENT LEVEE LOCATIONS—HUNTER CREEK VICINITY

Hydraulic Performance of Existing Levee System

The existing levee system changes the hydraulics of flooding in the Valley in the following ways:

- Prevents direct inundation of floodplain areas by overbank flows, but allows inundation indirectly as a result of floodwaters conveyed through the Swift Creek/Hunter Creek corridor and backwater from downstream flooded areas
- Controls the sequencing of flooding
- In areas protected by levees, limits erosion from high-velocity floodwaters moving over the riverbank and onto the floodplain
- Increases overbank flow velocities and depths in floodplain areas just downstream of the end of the levee.

The hydraulic performance of the current levee system is limited since it is not continuous and therefore does not isolate the floodplain from the river. During flood events, floodwaters flow onto the floodplain through the Swift and Hunter Creek corridor along the south valley wall. Floodwaters also flow across the floodplain east of the end of the levee, tending toward the lower southern Valley. In addition, backwater from downstream causes flooding of the floodplain adjacent to the levees.

While the current levee system does not eliminate inundation, it does provide protection against high-velocity flows that can cause erosion and channel realignment. This function was described above for the Church Dike. Other areas on the floodplain side of the levee system also receive protection from potentially damaging high-velocity flows. However, while the levee protects some areas from high-velocity flows, the negative impact on areas directly downstream of the end of the dike is exacerbated. Where the river is no longer constrained by the levees, the increased volumes of water in the channel flow over the natural riverbank, releasing increased levels of energy and causing greater damage to floodplain property.

The Federal Emergency Management Agency has identified limitations associated with the existing dikes in the Skokomish Valley:

"... Whether they are called flood-control berms, dikes or levees they all basically have the same effect and problems. While they may offer a certain level of protection for one individual, at the same time the water is being detoured to someone else who does not have the benefits of a berm. Berms also offer a false sense of security, often being overtopped or breaking, flooding those they were supposed to protect. This has been seen in recent flooding events." (Letter from Federal Emergency Management Agency to Mason County Board of Commissioners, March 17, 1996, see Appendix C).

The Sequencing Effect

The effect of the levee system on flood sequencing was evident during the December 20, 1994, flood. The existing levees did not increase peak flood levels during the flood, as many levees were breached and failed and some overtopped. Once this occurred, flood water inundated the entire Valley much as if the levees were not in place.

While the peak flood levels were similar to what they would have been without levees, the sequence of flooding was affected by the levees. As flow in the river increased, and prior to any levee breaks, more flow was contained within the channel corridor than would have occurred with no levees in place. This initially prevented overflow across the Valley and provided temporary flood protection to some residents located behind the levees.

At the downstream end of the existing levees, river water overflowed and traveled to the south side of the Valley toward Purdy Creek. The overflow across the Valley was more concentrated from the locations at the downstream end of the levees than they would have been without the levees in place. Without levees, overflow from the river would have occurred at more locations, but would still have flowed across the Valley to the south side.

As the flood continued to increase, the some levees overtopped or breached and flood waters flowed south across the Valley. The multiple overflow paths across the Valley following the levee breaches and overtopping diminished any effects of the levees on flood levels.

Comparison of Low-Level Berm to Existing Levees

The low-level berm alternative was developed through identification of high ground along the river and hydraulic modeling. Details of the analysis approach and analytical conclusions are presented below. The following list compares the low-level berm alternative to the existing levee network:

- The crest elevation of the low-level berms would be lower in most instances than the existing levees.
- The location of the low-level berms would be similar to the existing levees from about Swift Creek to the church. This alignment follows the natural high ground.
- From the Church downstream to the end of the existing levees, the berms would be set farther back from the river than are the levees. Existing levees would be removed or breached so that they would not function as levees.
- The low-level berm would be extended downstream to US 101, with a similar low-level ring berm around the properties along East Bourgault Road.

Alternatives

Alternatives developed for this CFHMP address both the existing levees and a new low-level berm. Alternatives addressing the existing levees focus primarily on how to maintain or modify the levees and on developing policies to guide these actions. Alternatives involving the low-level berm focus on the height and configuration of the berm. Hydraulic modeling of the existing levees was discussed above; therefore, most of the analytical work reported here concerns the low-level berm.

The following alternatives were developed to address the existing levees and the potential new low-level berm:

- Construct a new low-level berm set back from the river

- Dredge the river and use the dredged material to construct flood-control berms along the river bank from about the North and South Fork confluence to Hood Canal
- Extend the existing levee system downstream to US 101. Inspect dike across from the Skokomish Valley Church and take appropriate action
- Provide gaps in existing dikes
- Adjust crest elevations of existing dikes to provide a uniform level of protection
- Develop a policy on modifications to the current levee system and construction of new set-back berms.

Detailed hydraulic analysis was completed for the construction of a low-level set-back berm. Remaining alternatives did not require analysis, used the analytical results from the low-level set-back berm, or used analytical results reported above.

Low-Level Set-Back Berms: Analysis Approach

The 1993 Draft CFHMP presented a berm concept as a sketch, included with this report as Figures 6-19a through 6-19c. Detailed analysis of a revised berm alternative was completed as part of this CFHMP to document the effects of the berms on flood levels.

The objective of the analysis was to determine the berm height required to contain a range of flows between 4,000 and 21,500 cfs. The proposed berm would extend from the Swift Creek Bridge to East Bourgault Road. The analysis assumed no dikes in the Valley other than the proposed new berms.

The first step in the analysis was to determine the approximate alignment of the high ground of the overbanks. This is generally defined as the ground elevation along the overbanks that, if exceeded, would allow flood waters to be conveyed into the floodplain. This flow corridor was described above and is shown again here in Figures 6-20a and 6-20b.

The second step was to draw the berm alignments onto the 1:200 scale topographic mosaic. The proposed berm alignment roughly follows the alignment presented in the 1993 Draft CFHMP. As shown in Figure 6-20, the berm is located predominantly along the southern overbank of the mainstem of the Skokomish River. It extends upstream from East Bourgault Road to the Swift Creek Bridge. A section of berm is proposed along the southern edge of the Richart property just downstream and northeast of the confluence of the North and South Forks A set of berms is also proposed immediately upstream of the Skokomish River Slough Bridge on US 101 to contain overflows through the bridge.

In defining the alignment of the berms, it was decided that if a berm were to be constructed, it would make the most sense to align it along the highest ground elevation in the overbanks. The berm alignment generally coincides with the overbank high ground alignment. However, occasionally the berm alignment had to be shifted in order to smooth the alignment or to ensure that all structures were located outside the berm alignment.

Once the alignment of all proposed berms was drawn onto the maps, the third step was to create the HEC-2 data files that reflected the berm alternative. For this scenario, the no dike scenario HEC-2 files were used as a starting point, since the analysis assumed no dikes existed in the Valley other than the proposed new berms.

A range of flow rates was run through the series of HEC-2 models to establish the berm heights required at each of the cross-sections along the berm alignment. Flow rates simulated were 4,000, 6,000, 10,000, 16,200 (2-year event), and 21,500 cfs (5-year event). The results were compiled to determine how high a berm would have to be to contain flows within the channel for a given return frequency flood event at each cross-section.

Water surface elevations were determined at each cross-section for each of the flow rates. The berm height required to contain a specific discharge was determined by subtracting the water surface elevations at each cross-section from the ground surface elevations at that cross-section. Required berm heights are presented in Figures 6-20a and 6-20b.

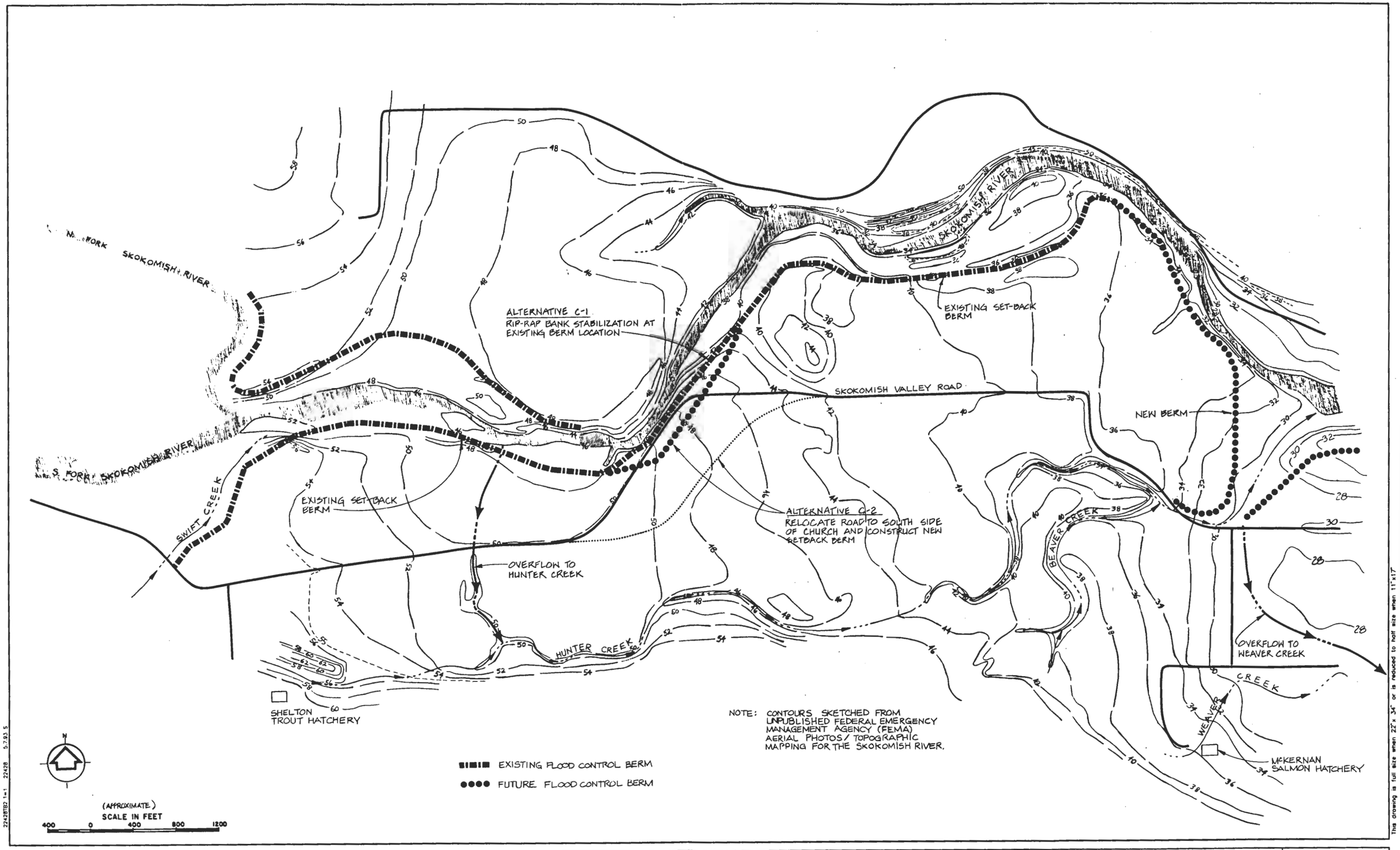
A final analytical step documented the effect of the berm on water surface elevations. The water surface elevations predicted for the low-magnitude flood events with the berms in place were compared with the water surface elevations predicted for the 100-year event with no dikes or berms in place. The rationale for this comparison is explained below.

Low-Level Set-Back Berms: Compliance with FEMA Regulations

If agricultural berms were constructed along the proposed alignment for a given return frequency, the flood flows of that frequency would be contained within the boundaries established by the berm system. The floodplain would no longer be available for conveyance of flows that would normally overtop the high ground of the overbanks. Therefore, for a given return period flood event, the computed water surface elevation at a given cross-section with the berms in place will generally be greater than or equal to the computed water surface elevation at that cross-section without the berms in place. This conclusion is valid only if the berms contain all the flood flows, are not circumvented upstream, and do not breach or fail.

Taking this one step further, for a given return period flood, not only is it entirely possible that the computed water surface elevation at a given cross-section with the berms could be greater than the computed water surface elevation at the same cross-section without the berms, it is also possible that, for the same return period, the computed water surface elevation with the berms in place could actually be greater then the 100-year base flood elevation. In other words, it is possible that the water surface elevations resulting from a 5-year flood behind an agricultural berm built to contain the 5-year event could be higher than the 100-year water surface elevations with no dikes in place. This possibility is shown in Figure 6-21.

According to FEMA regulations, no structure built within a floodway can raise the base flood elevation more than 1 foot anywhere in the floodplain. Depending on the height of the agricultural berm, this regulation could be violated. This regulation requires that, at any cross-section, the elevation of the top of the berm cannot be built any higher than 1 foot above the 100-year base flood elevation.



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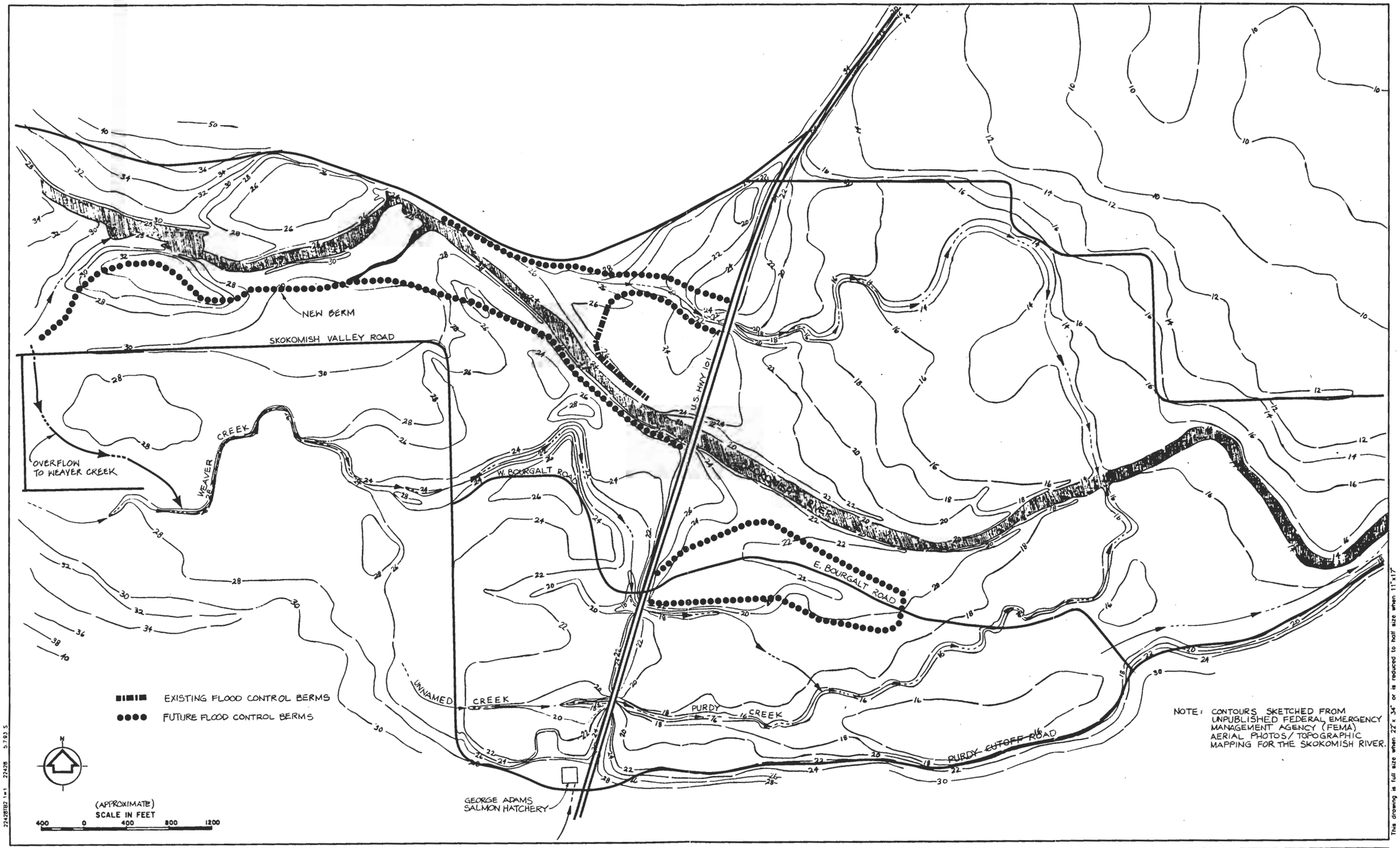

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Figure 6-19b.
1993 PROPOSAL FOR FLOOD CONTROL BERMS WEAVER/PURDY CREEK VICINITY

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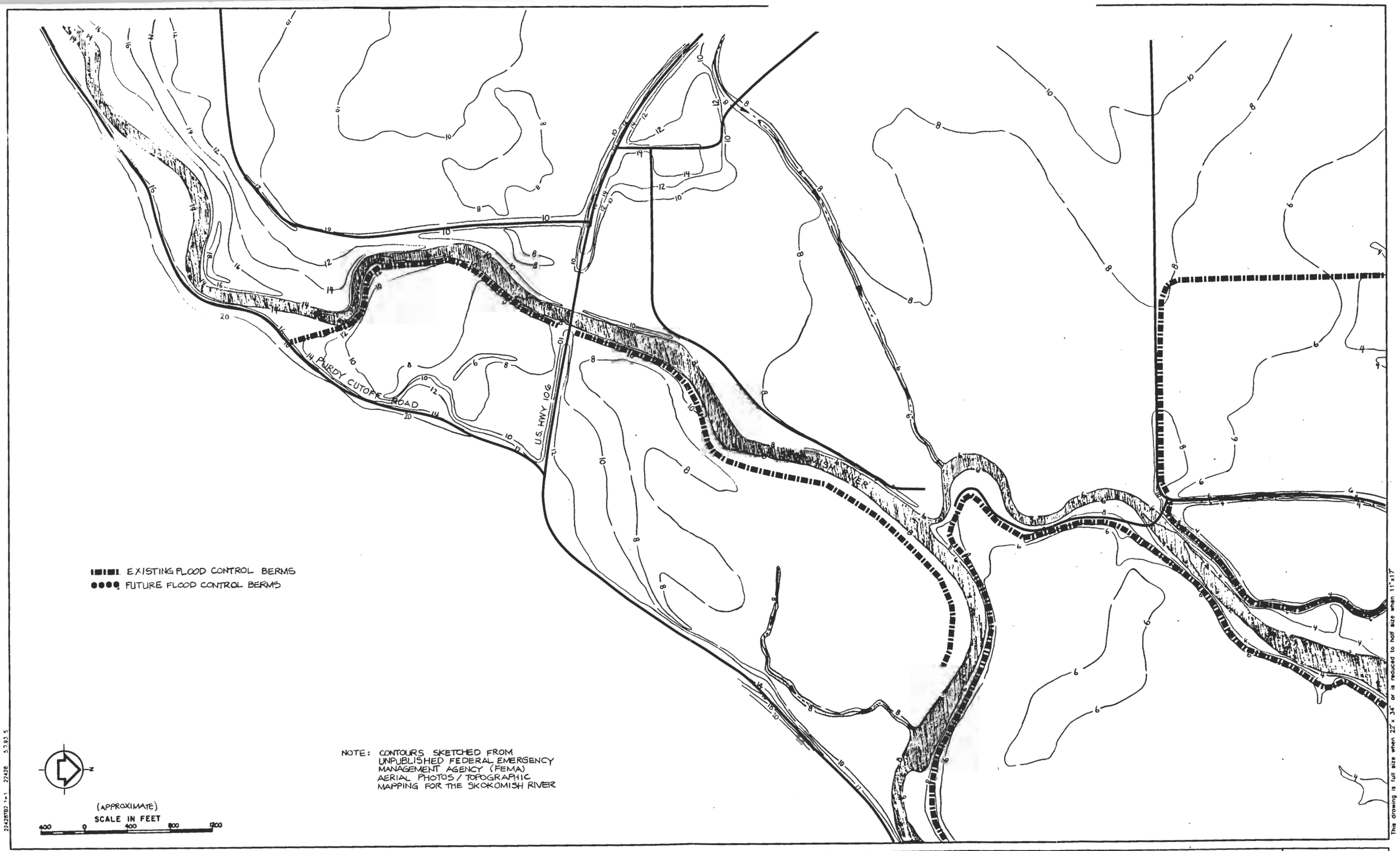

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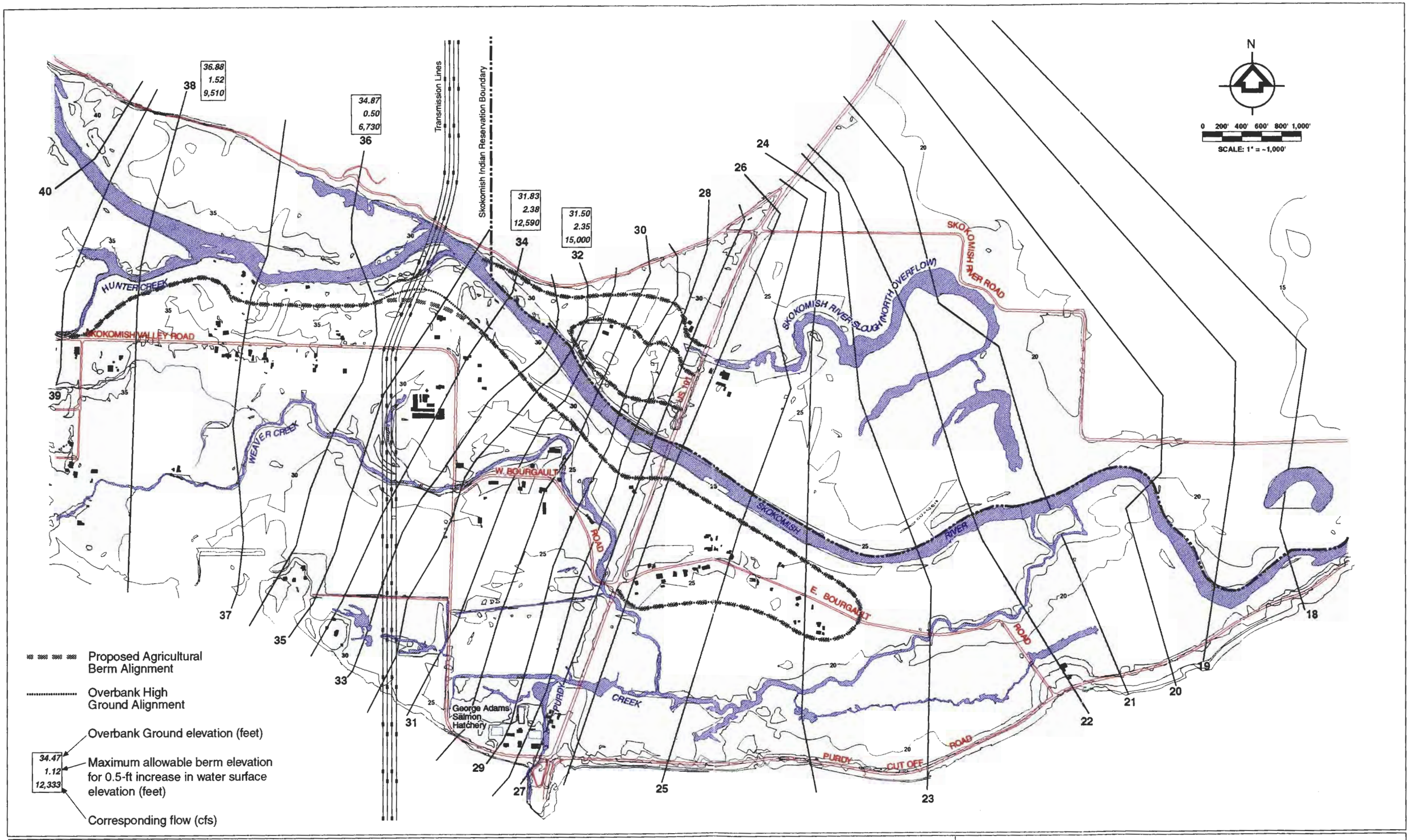

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Figure 6-20a.
MAXIMUM ALLOWABLE BERM HEIGHTS—WEAVER CREEK VICINITY

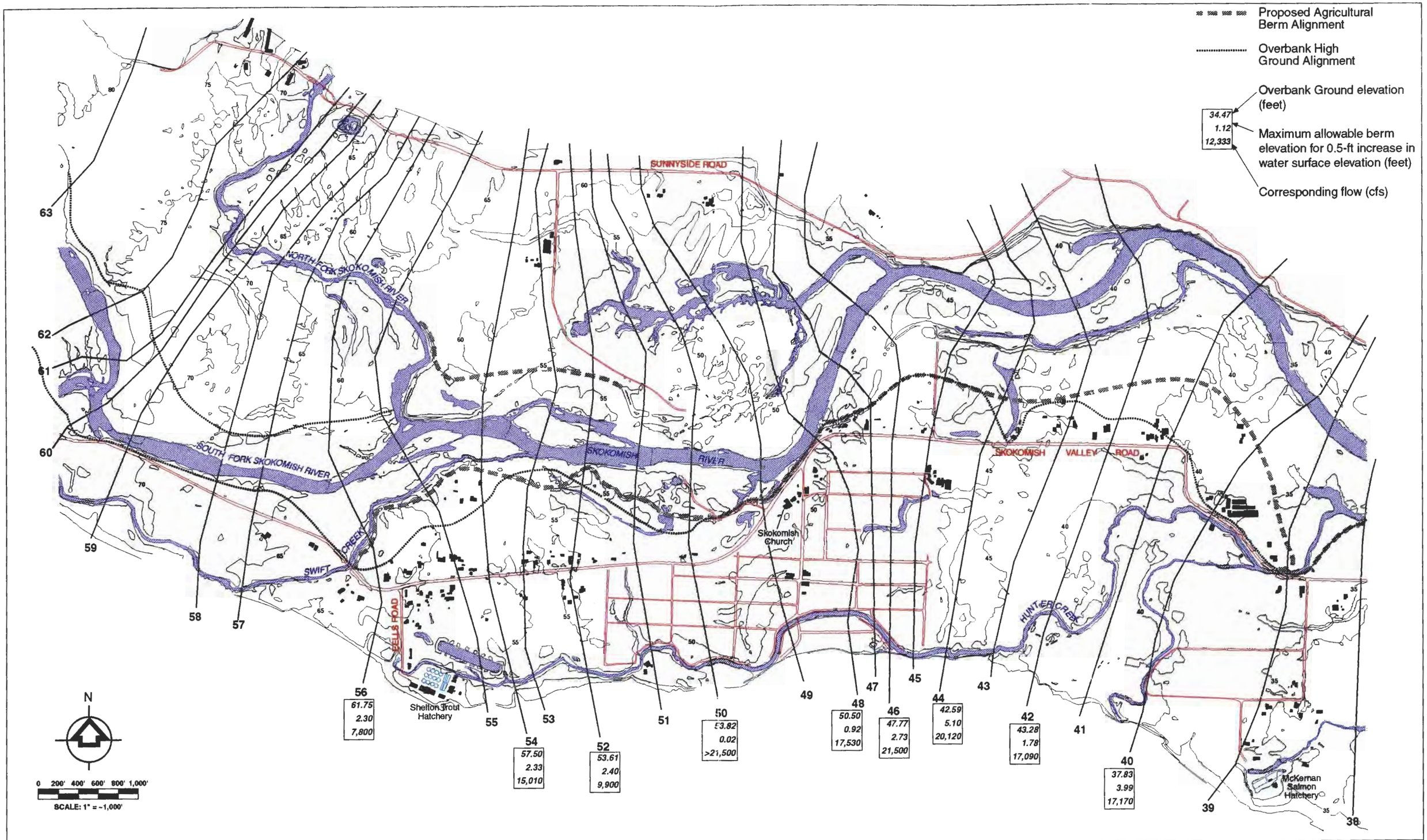

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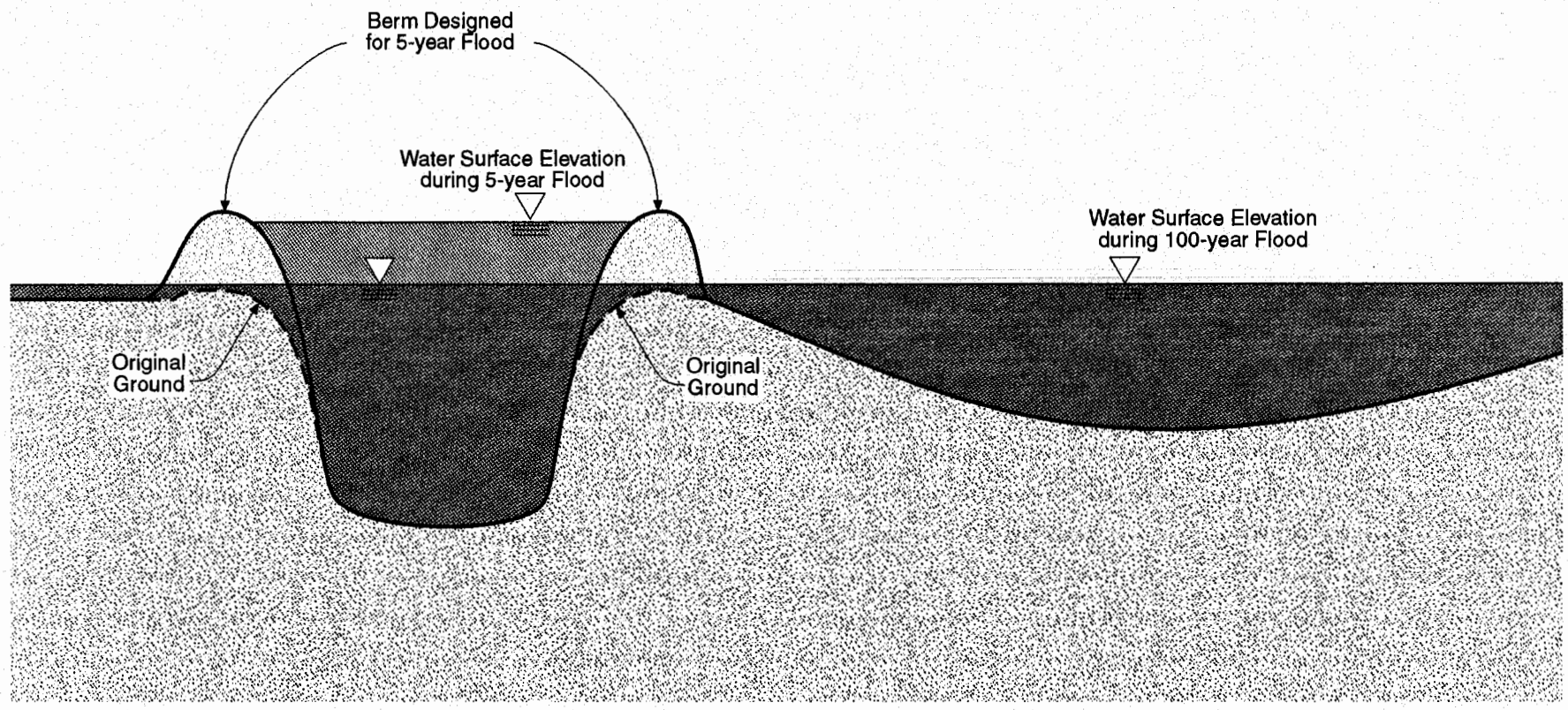
Figure 6-20b.
MAXIMUM ALLOWABLE BERM HEIGHTS—
HUNTER CREEK VICINITY



KCM *1917 First Avenue* *Seattle, Washington 98101*	Mason County SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN	Figure 6-21. FLOOD LEVELS RESULTING FROM 5-YEAR FLOOD WITH 5-YEAR BERM AND 100-YEAR FLOOD WITH NO BERM

In light of this requirement, a comparison was made between the 100-year base flood elevation and the range of berm heights required for each of the five flow rates modeled. The comparison included the maximum top of berm elevation assuming a 0.5-foot increase in base flood elevations and assuming a 1.0-foot increase in base flood elevation. The 0.5-foot increase was included in the analysis because it forms the basis of an agreement between Ecology and Mason County (see Appendix FF). The maximum top of berm elevation for each of these two scenarios was then converted to a maximum allowable flow rate that could be contained behind a berm at each cross-section. These maximum allowable flow rates are listed in Table 6-19 and presented in Figures 6-20a and 6-20b.

TABLE 6-19.
MAXIMUM ALLOWABLE FLOW RATES UNDER LOW-LEVEL BERM SCENARIO WITH 0.5-FOOT RISE

Section Number	Maximum Allowable Flow Rate (cfs)[a]
32	15,000
33	14,820
34	12,590
35	10,000
36	6,730
37	7,040
38	9,510
39	12,830
40	17,170
41	18,720
42	17,090
43	17,340
44	20,120
45	>21,500
46	21,500
47	18,770
48	17,530
49	20,410
50	>21,500
51	>21,500
52	9,900
53	12,870
54	15,010
55	16,880
56	7,800

a. Determined by adding 0.5 feet to 100-year flood stage and calculating flow rate corresponding to resultant stage.

Low-Level Set-Back Berms: Analytical Conclusions

A comparison of the maximum allowable berm heights with the berm heights required to contain the 2- and 5-year floods is presented in Table 6-20. The average heights required to contain the 2- and 5-year floods between US 101 and the confluence of the North and South

Forks are approximately 3.0 and 3.9 feet, respectively. The average allowable berm height is 2.5 feet. This indicates that, on average, the maximum allowable berm height would provide protection from floods having a greater than 50 percent chance of occurring every year.

TABLE 6-20.
COMPARISON OF MAXIMUM ALLOWABLE BERM HEIGHTS
TO BERM HEIGHTS NEEDED TO CONTAIN THE 2- AND 5-YEAR FLOOD

HEC-2 Cross Section Number	Overbank Ground Elevation	Max Berm Elevation Assuming 0.5 Ft. Increase	Maximum Allowable Berm Height Assuming 0.5 Ft. Increase	16,200 cfs Water Surface Elevation	16,200 cfs Depth Above Overbank Ground	21,500 cfs Water Surface Elevation	21,500 cfs Depth Above Overbank Ground
24	24.40	28.89	4.49	28.41	4.01	29.05	4.65
25	26.60	29.71	3.11	29.25	2.65	29.95	3.35
26	28.10	31.70	3.60	31.76	3.66	32.58	4.48
27	28.00	32.62	4.62	32.61	4.61	33.71	5.71
28	28.40	32.85	4.45	32.76	4.36	33.85	5.45
29	29.00	33.05	4.05	33.11	4.11	34.24	5.24
30	28.00	33.51	5.51	33.56	5.56	34.72	6.72
31	30.30	33.81	3.51	33.95	3.65	35.15	4.85
32	31.50	33.85	2.35	34.17	2.67	35.40	3.90
33	31.90	33.93	2.03	34.30	2.40	35.51	3.61
34	31.83	34.21	2.38	35.27	3.44	36.53	4.70
35	34.68	34.64	-0.04	36.49	1.81	37.74	3.06
36	34.87	35.37	0.50	39.05	4.18	40.46	5.59
37	35.34	36.66	1.32	39.75	4.41	41.14	5.80
38	36.88	38.40	1.52	40.45	3.57	41.80	4.92
39	35.89	39.74	3.85	40.75	4.86	42.09	6.20
40	37.83	41.82	3.99	41.58	3.75	42.89	5.06
41	40.61	43.87	3.26	43.37	2.76	44.42	3.81
42	43.28	45.06	1.78	44.89	1.61	45.90	2.62
43	44.55	45.95	1.40	45.72	1.17	46.74	2.19
44	42.59	47.69	5.10	46.98	4.39	47.94	5.35
45	46.58	48.84	2.26	47.59	1.01	48.52	1.94
46	47.77	50.50	2.73	49.71	1.94	50.51	2.74
47	49.21	50.99	1.78	50.66	1.45	51.34	2.13
48	50.50	51.42	0.92	51.25	0.75	51.93	1.43
49	50.84	52.49	1.65	51.91	1.07	52.64	1.80
50	53.82	53.84	0.02	52.71		53.45	
51	54.75	55.04	0.29	54.26		54.85	0.10
52	53.61	56.01	2.40	57.38	3.77	58.23	4.62
53	54.99	57.94	2.95	58.60	3.61	59.45	4.46
54	57.50	59.83	2.33	60.03	2.53	60.82	3.32
55	61.29	61.39	0.10	61.30	0.01	62.00	0.71
56	61.75	64.05	2.30	65.78	4.03	66.61	4.86
Mean			2.50		3.03		3.92

Maximum allowable berm height = (water surface elevation from 100-year flood + 0.5 feet allowable rise) - overbank ground elevation

Average flows allowable assuming a 0.5-foot rise in base flood elevations are approximately 15,600 cfs, while flows allowable assuming a 1.0-foot rise in base flood elevations are approximately 17,000 cfs. The 5-year flood discharge at US 101 is 21,500 cfs.

With the low-level berms in place leading up to US 101, and downstream from US 101 around the residences along East Bourgault Road, the flood events described above will be contained within the river corridor. This means that for flows up to that magnitude, more water will flow through the main channel bridge with less water flowing through the Purdy Creek bridge.

Both with and without low-level berms, the two flow paths from Purdy Creek and the main river channel join downstream from East Bourgault Road. The effect of low-level berms would be to increase flows through the main river channel bridge opening to levels that existed years ago when this section of the river had a greater flow capacity.

Low-Level Set-Back Berms: Additional Issues

Several additional issues would need to be resolved if a new system of berms were to be constructed. These additional issues are discussed below.

Construction on Private Property

In the past, levees have been constructed on private property mostly by the property owners themselves. Setting the low-level berm farther back from the river, as well as extending the berm into new areas, will require the permission of the affected property owners. Without this permission, the low-level berm option will not likely be implementable.

Uniform Crest-Height Berm

The low-level berm option was conceived as having a uniform crest elevation throughout the length of the berm, thereby affording the same level of protection to all properties in the floodplain. This approach would change where the river overflows its banks, assuming the existing levees were not in place.

A variation is to construct the berms at a uniform height. For example, the berm could be built 3 feet above the high ground adjacent to the river. This alternative would provide containment of different flood magnitudes, depending on location and the river corridor capacity at each location. This alternative, however, maintains the initial flood overflow locations as they would occur with natural ground elevations. Low points along the river will continue to be low points and the first areas for overflow into the valley. The role of the low-level berms in this case would be to contain an additional 3 feet of water in the river corridor before overflow occurs. As with the berms described above, once they are overtopped during an extreme flood, flooding of the Valley will be similar to the case with no berms in place.

Level of Protection Limitations Due to Hunter Creek

Regardless of the berm alternative, the level of protection provided will be limited because an opening in the berm would be required at the outlet of Hunter Creek. The berms can extend upstream along Hunter Creek only as far as the roadway crossing. When the water level in the river exceeds the roadway elevation, flooding will occur along Hunter Creek near the bridge crossing. Since Hunter Creek will act as an overflow relief valve for flood flows in the Skokomish River, there would be no benefit in constructing berms higher than this.

Gate controls might be considered to improve the level of flood protection at this location. If gate controls are installed at the Hunter Creek outlet, the level of protection could be increased. Gate controls are not recommended by this CFHMP for several reasons. They are expensive, require extensive maintenance, are not historically reliable, and often present a barrier to fish passage. Raising the Skokomish Valley Road near the Hunter Creek bridge crossing is another possible improvement that might contain flows in the creek and river and thereby increase the level of flood protection. This would be expensive and would encroach on the property and possibly the houses of adjacent property owners.

Dredge the River and Use the Dredged Material to Construct a Continuous Berm

This alternative is not feasible for several reasons, already discussed in connection with the existing levee system and the proposed low-level berms. Material dredged from the river would not be suitable for direct use in construction of levees. Experience with the current levee system has shown that appropriate materials must be used and engineering standards followed if a levee is to provide dependable protection for an extended period of time.

Levees constructed along the riverbank are unlikely to meet FEMA standards while providing any significant level of protection. As shown in the analysis for the low-level set-back berm, the greatest level of protection that can be accomplished while still meeting FEMA standards is protection from a 2- to 5-year event. A levee constructed closer to the bank of the river will cause river stages to increase, thereby reducing the levee height that is allowable.

Providing Gaps in Existing Dikes

Providing gaps in the current dike system would result in more frequent inundation of floodplain land adjacent to the gaps due to the lower discharges necessary to cause flooding. More severe damage would occur to property adjacent to the gaps by more frequent inundation and higher velocity flows through these areas.

The higher velocity flows caused by gaps in the current dike system could bring about a catastrophic change in river alignment. As described previously, overbank flows tend to be conveyed to the south across the floodplain. There are currently several preferred pathways for overbank flow toward the south Valley, determined by topographic depressions in the floodplain. Construction of gaps in the current dike system may exacerbate this problem, with high-velocity flows potentially eroding a new channel across the floodplain.

Adjust Crest Elevation of Current Levees to Same Level of Protection

Adjusting the crest elevations of the existing levees to a uniform level of protection would provide some limited benefits to a limited area of the floodplain. As described above, because the levees are not continuous, they do not prevent inundation of the floodplain. This would remain the case if the crest elevations of the levees were increased.

Increasing the crest elevations of the existing levees would provide additional protection from high velocity flows for property adjacent to the levees. By increasing crest elevations, more water will stay in the channel along the reach protected by the levees, and the smaller amounts of water that do flow over the levee will have less energy to cause damage. However, by increasing the amount of water in the channel along the protected reach, damage will be

exacerbated in areas downstream of the end of the levee. The additional force of the increased flows is more likely to cause a channel avulsion where the river is not constrained by the levee.

Develop a Policy on Modifications to the Current Levee System and Construction of Set-Back Berms

The PAC devoted a great deal of effort to developing a proposal that would provide balance between those in favor of using dikes to protect agricultural land and homes and those who believe the protection afforded by dikes is outweighed by their impact on the environment and adjacent property. On October 24, 1995 the Planning Advisory Committee adopted a policy on dikes. Agreement was reached that: "Diking is not a preferred alternative for addressing flooding in the Valley, but there are instances where dikes can provide legitimate flood protection." The Planning Advisory Committee recommended as a priority completion of a reconnaissance analysis of existing dikes "to develop recommendations for removal, abandonment, or approval for maintenance and upgrading" to meet its approved minimum standards for dike construction, alteration and maintenance. Under the PAC's recommended diking policy, "Applications for construction, alteration and maintenance of dikes shall be considered on a case-by-case basis." The full policy is as follows and its adoption is recommended in this report.

1. Diking is not a preferred alternative for addressing flooding in the Valley, but there are instances where dikes can provide legitimate flood protection.
2. Though dikes were originally constructed in the Valley with the intention of providing protection and safety, existing dikes generally do not meet standards adopted in this plan.
3. Construction, alteration and maintenance[1] of dikes shall meet the following design and construction standards. The intent of these standards is to ensure that dikes meet basic structural standards, do not cause increased flood hazard, meet FEMA requirements[2] and are distanced from the natural stream channel and stream bank.
    a. Dikes shall be constructed to meet Soil Conservation Service Class II standards for compaction.
    b. Dikes shall be designed and constructed to overtop at the 5-year return period flood or lesser event and shall comply with FEMA standards[3]
    c. Dikes in designated overflow zones shall be required to overflow at lesser flood events than the maximum established in b above.
    d. Dikes shall be set back from the channel at least 200 feet. Variance criteria will be established at the time these policies are enacted through an ordinance.
    e. Dikes shall be constructed with a minimum side slope of 2:1 for the riverside embankment and less steep minimum side slope of 5:1 for the landside embankment. Variance criteria will be established at the time these policies are enacted through an ordinance.

f. Dikes shall not increase flood hazard for public or private interests.

g. Satisfaction of design and construction standards (a-e above) shall be certified by a qualified engineer licensed in the State of Washington.

4. Establish a process for analyzing each existing dike to develop recommendations for removal, abandonment, or approval for maintenance and upgrading to meet standards of #3, above. This analysis shall include planning level cost estimates and identification of any public benefits that would justify use of public funds.

5. Applications for construction, alteration and maintenance of dikes shall be considered on a case-by-case basis. Examination of individual cases shall consider any analyses performed in 4 above. Applicants claiming public benefits and proposing use of public funds shall provide justification. Applicants shall be required to show intent and ability to meet anticipated maintenance costs.

1 The work necessary to preserve or restore the natural condition or to restore man-made flood control facilities to their former condition using in-kind replacement materials or acceptable alternatives. This work is necessary due to anticipated or actual damage or destruction from flooding by action of erosion, stream flow, sheet runoff, or other damages by the sea or other bodies of water.

2 The allowable rise in water surface elevations during the 100-year flood event due to dikes has been agreed to be one half (0.5) foot

3 No consensus was reached on this point by the Planning Advisory Committee. There were some members of the Committee who did not want to establish a limit on dike height. However, the general will of the Committee was to establish a 5-year overtopping standard (PAC 1995).

Recommended Action

As described above, the policy on diking provides a coherent set of policy statements and procedures to manage and, as needed, modify the levee system in the Skokomish Valley. A process is recommended whereby each section of existing dike is analyzed and recommendations are developed for action.

The low-level berm analysis completed for this CFHMP provides critical information that can be used if the result of analysis of a particular section of dike indicates that a set-back dike is the appropriate approach. Low-level berm heights, locations, and predicted hydraulic performance information presented here can be used to develop detailed designs if this approach is taken at any location.

Prior to modification of the existing levee system or detailed design of any section of the low-level berm, a detailed reconnaissance report should be completed as part of the process required by policy item 4 above. The report would serve the following purposes:

- Establish priority of future projects
- Establish a realistic budget for bringing the dikes into compliance with existing policy

- Make future permitting decisions on private dike repair requests
- Determine the degree to which each dike provides private as opposed to public benefits.

Implementing the policy on diking is of great concern to the community and is therefore a priority in this CFHMP. It follows that the reconnaissance report must also be a priority.

Process for Completing Reconnaissance Report

The first step in development of the levee system policy report is the development of criteria upon which management decisions for sections of the system can be made. The following example is based on the criteria used by Snohomish County:

1. *Technical Feasibility* - Management strategies must be technically feasible. For example, new dikes are not possible in some locations where underlying wetlands soils will not allow for settlement. Ideally, the alternatives available for each situation would be pared down based upon the engineering and technical requirements of the site.

2. *Benefits vs. Costs* - Dikes are expensive to build, repair, and maintain and the ability of the public to pay is limited. In evaluating management alternatives, these costs must be weighed against the dike's benefits, considering both the economic and social value of the protected lands.

   Benefits should be divided into public benefits and private benefits, and costs allocated proportionately. Flood damage reduction benefits over the entire river system should exceed long-term costs. Societal values can play an important role in identifying benefits and costs. Opportunities to achieve secondary public benefits such as public access for recreation activities such as hiking, fishing, and wildlife observation should also be considered.

3. *Public Safety* - Buildings and lands within the floodplain are subject to safety risks and property damage caused by high flows and channels shifts. Dikes reduce, but do not entirely eliminate, these problems for protected areas. Dikes can also aggravate flooding and erosion problems on adjacent un-diked lands by blocking off floodwater storage areas and restricting flow conveyance.

   When evaluating alternatives, the type and severity of safety problems that might be corrected or created by each alternative should be considered. For example, if human life is currently endangered, the project should be designed to eliminate the danger. If there is currently no risk to human life, the project should create such a risk.

4. *Environmental Impacts* - Various kinds of potential environmental impact are associated with dikes. Dikes can block off valuable side-channels that provide salmon rearing habitat and refuge during high-water events. Dikes can channelize flows, leading to increased channel scouring in some areas, as well as bank erosion. Dikes can affect existing wetlands as a source of fill and as an unnatural interruption to the wetland's hydrologic regime. The net

environmental impact of any diking project (including any mitigation measures) over the long term should be either beneficial or insignificant.

5. *Consistency with Applicable Land Use Plans and Regulations* - The project should be consistent with land-use regulations governing activities in the floodplain and riparian corridor, and with county policies intended to minimize development in hazardous areas. Examples of such regulations and policies for the Skokomish Valley are the density criteria recommended in this CFHMP for the County's floodplain ordinance.

Following evaluation of each levee section based on the criteria, a preferred alternative(s) should be selected. The following list of potential alternatives is based on the approach used in Snohomish County:

1. Continue the current level of dike maintenance and repair procedures and responsibilities.
2. Continue current maintenance procedures until a dike is damaged in a flood event. If damage occurs, evaluate whether to:
   a. Allow repair of the dike to its pre-existing condition and continue previous maintenance responsibilities
   b. Require repair of the dike with an improved design, that may include:
      i. Set the dike back from the river's edge in accordance with the 200-foot set-back standard.
      ii. Reduce the side slopes to comply with the minimum riverside and landside slope standards of 2:1 and 5:1, respectively.
      iii. Improve compaction to bring dike into compliance with SCS compaction standards.
      iv. Lower the dike to comply with overtopping standard for 5 year return period flood.
      v. Realign the dike to prevent impact on adjacent properties
3. Require that immediate action be taken to alter dike design
4. Require that dike be abandoned or removed
5. Determine whether a better alternative exists, such as bank stabilization or moving structures
6. Determine whether a particular set of circumstances warrants maintaining a dike that varies from the design standards. An example would be to allow a dike to be maintained that is closer than 200 feet to the bank, or has steeper than standard side slopes.

A detailed discussion of standards, construction procedures, potential impact, costs, and funding recommendations for diking is presented in Appendix GG of this report.

Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Promote flood control strategies that will be effective in reducing the degree and severity of floods in the Skokomish Valley (objective).
- Remain eligible for all the benefits and assistance available through the Federal Emergency Management Agency (FEMA) by adopting a floodplain map and Comprehensive Plan that meet FEMA's requirements for flood hazard management (objective).
- Identify areas that cannot be adequately addressed in the current Plan due to funding and time constraints, and recommend that these areas be phased into the Plan as practical (action).

ISSUE 9: FLOOD PROTECTION FOR INDIVIDUAL PROPERTY OWNERS

Because flooding will always be a threat in the Valley, residents should consider floodproofing their homes. Many homes in the Valley already have floodproofing of one kind or another. Philosophically, floodproofing is a different approach to flood hazard management than some of the alternatives previously described. It accepts the occurrence of floods and only seeks only to protect structures from damage due to the floods.

Floodproofing is defined by the COE as "Any additions, changes, or adjustments to properties and structures which reduce or eliminate flood damage to lands, water and sanitary facilities, structures, and contents of buildings" (COE 1984). Floodproofing actions can be required for future development as well as implemented on existing buildings.

While floodproofing does not provide complete protection during extreme flood events, it can be combined with other flood hazard management measures to reduce flood damage. Floodproofing may keep a building in use during flood periods. Floodproofing also increases the protection provided by other partial-protection flood control projects, improves opportunities to obtain flood insurance, and can improve community awareness of flood risks.

Homes and outbuildings in the Valley have been flooded often. Construction of many of these structures predates the preparation of flood insurance rate maps by FEMA and County ordinances regulating floodplain development. Recommendations in to Issues 6 and 7 are valley-wide approaches to development, intended to reduce flood damage to new structures. Floodproofing approaches described in this section can be used for existing or new structures.

Alternatives

The two alternatives developed for this issue differ in the groups responsible for implementation. Furthermore, implementation of the first alternative will facilitate implementation of the second. The alternatives are as follows:

- Provide information to residents on actions that they can take prior to, during, and after a flood that are specific to their location and residence. Provide detailed recommendations on floodproofing specific structures based on costs and benefits of actions to protect structures from site-specific hazards
- Complete floodproofing for specific structures. Projects may include structure elevation, floodwalls and levees, closures and sealants, and sandbag dikes.

The first alternative is currently being completed by the COE under a project called a flood audit. Once this project is complete, Valley residents will have detailed information to complete individual floodproofing projects. The following sections describe the flood audit and common approaches that residents can use for floodproofing.

Corps of Engineers Flood Audit

The COE, through an agreement with FEMA, is in the process of completing a flood audit of the Skokomish River Valley. The flood audit will provide information on specific flood hazards at habitable structures in the valley. The goal of the flood audit is to provide each resident with information on actions to take prior to, during, and after a flood that are specific to their location and residence. The major activities being completed by the COE include the following:

- Field reconnaissance will be completed to collect elevation data and record structural characteristics
- The Nonstructural Evaluation computer program, developed by the Sacramento District of the COE, will use data collected in the field and predictions of floodwater elevations to evaluate costs and benefits of a variety of nonstructural measures
- A packet of materials will be prepared, including the results of the flood audit program and other site-specific information, and mailed to each resident.

Field Reconnaissance

Measurements will be made during the field reconnaissance to determine the ground elevation at each structure and the elevation of the lowest habitable floor. Information on the type of structure (e.g., one/two-story, basement, wood frame), and its floor area will also be collected. No measurements are planned to be collected from inside the structure.

Nonstructural Evaluation Computer Program

The following data and data sources are used to prepare input to the nonstructural evaluation computer program:

- Data for ground elevation, elevation of lowest habitable floor, type of structure, and floor area, collected in the field
- Water surface elevations for a range of flood frequencies as predicted by the HEC-2 model
- The monetary value of each structure and contents

- Other variables, such as the average annual interest rate and the level of protection (e.g., 100-year flood) as selected by the program user.

The program is then run to calculate the costs and benefits associated with the following nonstructural measures that can be used to provide flood protection:

- Installation of closures over doorways, windows, and other openings prior to a flood event to prevent entry of water into the structure during the flood event. Temporary closures are typically not used for depths greater than 3 feet above the first floor because existing walls and foundations are not designed for the hydrostatic loads that would result
- Construction of a levee made of soil or other material that completely encircles the structure (also called ring levees)
- Construction of concrete or masonry vertical walls that surround the structure. Walls are used instead of levees where space is limited or where flow velocities or wave action may be an additional flood hazard
- Placement of soil fill to establish a ground surface for future construction of a structure that has a first habitable floor elevation above the flood water surface. Construction of a new structure is not included in this alternative
- The existing structure is raised in place so that the elevation of first habitable floor is above flood stage
- Moving the existing structure to a new location within two miles.

Costs for each of these alternatives are calculated internally by the program based on unit cost tables developed for each alternative.

Depth-damage curves that relate the depth of floodwaters to monetary damages from floods of different return periods are included within the flood audit program. Floodwaters of greater depth are assumed to cause greater damage, with the upper limit on damage being the total value of the contents and structure.

Information produced by the program can be used to determine which of the measures is preferred to protect against floods of specific return periods. A table of costs and benefits for each measure is presented for specified flood events. A graph of costs and benefits for the entire range of flows is also prepared for each measure. The specific flood frequency at which benefits will exceed costs can be determined from the graph so that the most cost-effective alternative can be selected to achieve desired levels of protection.

Mailing to Floodplain Residents

A packet of information will be mailed to each floodplain resident following the field reconnaissance and computer analysis described above. The mailing is intended to educate residents to deal with the specific flood hazards that may occur on their property. The following information may be included in the mailing:

- A transmittal letter describing the background of the flood audit, a description of the materials in the packet, and contacts available to answer questions

- Lists of actions to take before, during, and after the next flood
- A graphic relating the height of portions of the habitable structure to stages associated with floods of various frequencies and the stage at which flood warnings are given
- A graphic showing the elevations along the evacuation route for a particular residence and river stages
- Output from the flood audit program as described above
- Neighborhood information on flood levels of various frequencies and first floor elevations
- Listings of houses below flood warning level, with resident names and phone numbers
- A local map showing the expected areas of inundation from floods of various frequencies.

An example of the information packet that will be mailed to residents is included with this report as Appendix HH.

Common Floodproofing Approaches

Different methods of floodproofing are appropriate for providing protection from different flood hazards. The purpose of this section is to identify reasonable floodproofing methods for the Skokomish Valley and to provide some guidance for construction or implementation. Appendix S contains summary sheets describing the following floodproofing approaches:

- Raising or Moving the Structure
- Construction of Barriers
- Wet Floodproofing.

Further information can be obtained from the FEMA publications *Design Manual for Retrofitting Flood-prone Residential Structures* (FEMA 1986a) and *Floodproofing Non-Residential Structures* (FEMA 1986b).

Floodproofing techniques are classified according to the type of protection they provide. Permanent floodproofing techniques are always in place and require no action when flooding occurs (e.g., flood walls and levees, closures and sealants, elevation, relocation). Contingent floodproofing techniques require installation prior to flood occurrence (e.g., flood shields, watertight doors, movable floodwalls). Emergency floodproofing techniques are improvised when flooding occurs (e.g., sandbag dikes, earth-filled retaining walls). The most common floodproofing methods are described below. They can be applied to existing or future structures prone to flood hazards. Other techniques exist, and information explaining these techniques and their evaluation is available in the references cited above.

Structure Elevation

This technique involves raising structures to an elevation above the flood hazard. Structures may be elevated on columns, fill material, foundation walls, or other foundation types.

Structure elevation is a permanent measure, and usually requires little action when preparing for a flood. If done correctly, elevating a structure can eliminate flood damage in all but the most severe floods. Figure 6-22 shows examples of structure elevation floodproofing.

Floodwalls and Levees

Traditionally, floodwalls and levees have been considered structural alternatives to protect large areas or numerous structures. However, these methods can be applied to single structures within flood-prone areas.

Floodwalls and levees act as barriers, keeping flood waters away from structures. Floodwalls are generally concrete or masonry walls of various configurations that may encircle entire structures, protect only the lower elevations of the structure, or be built only around threatened openings of structures. Levees are earth-filled embankments with low to moderately sloped sides. Levees require a greater amount of space and typically require more maintenance. Floodwalls and levees can be used to protect any type of structure and require no alterations to the structure. Figure 6-23 shows examples of floodwall and levee floodproofing.

Closures and Sealants

Closures are permanent or temporary floodproofing measures that cover openings to limit water entrance a structure. They can be as simple as panels placed over a door, or as extensive as filling openings with water-resistant material such as concrete. Temporary closures require sufficient warning time so that they can be properly installed prior to flooding. Closure systems are most effective when there are a limited number of openings. Having closures on many openings may result in excessive leakage.

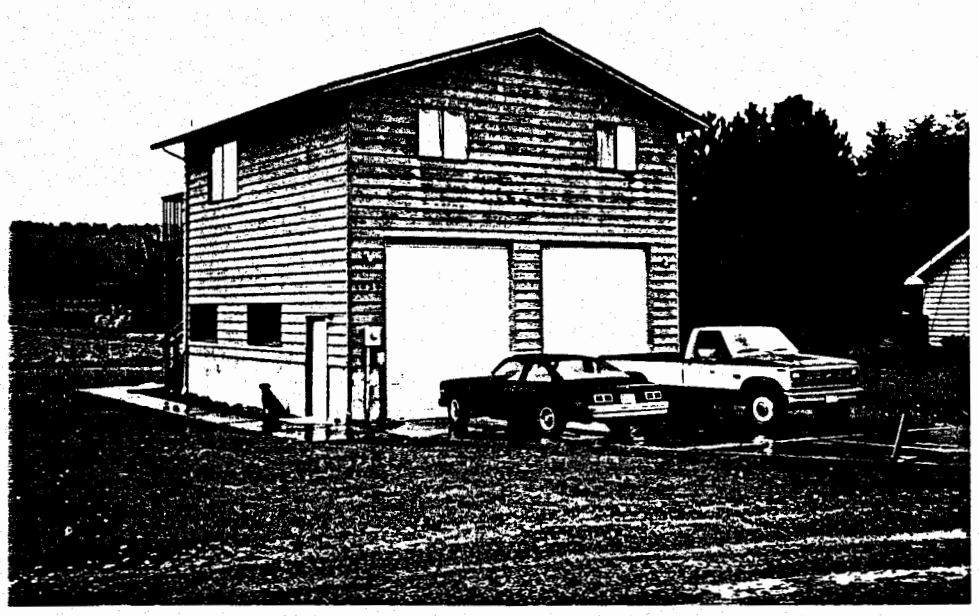
Closure leakage can be reduced by using sealants or gaskets to ensure watertightness. Sealants are waterproof coatings applied to any type of closure to reduce permeability. The coating is typically painted or sprayed onto walls or closures. Because of the significant hydrostatic pressures exerted on walls retaining flood waters, closures and sealants are recommended only for buildings with sufficient structural integrity to withstand these forces. Figure 6-24 shows examples of closures and sealants.

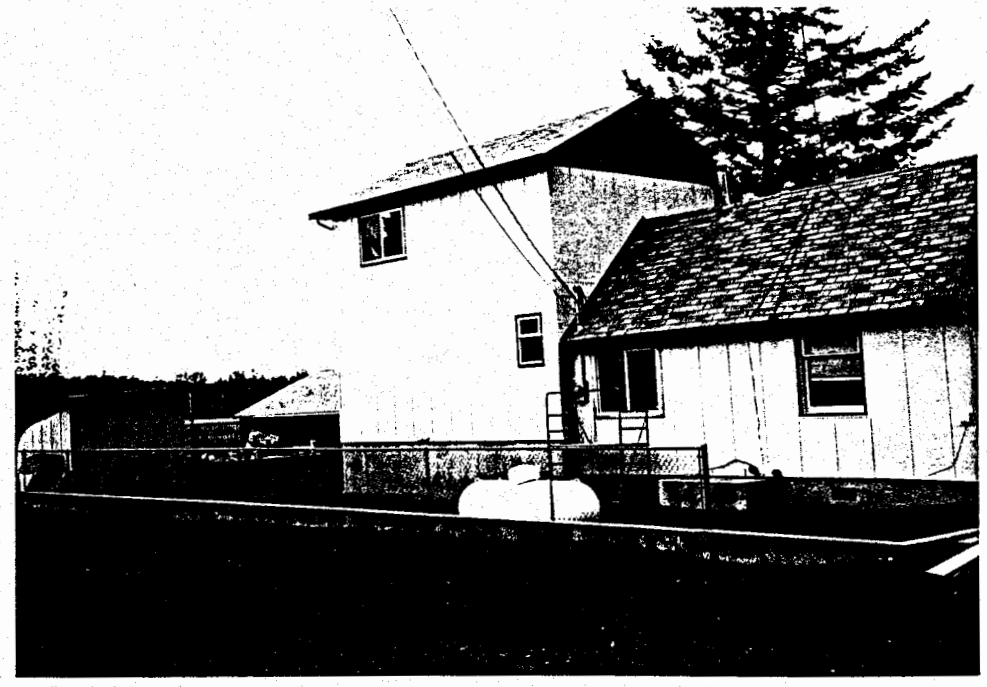
Sandbag Dikes

Sandbag dikes are an emergency floodproofing measure that can be put in place quickly using stored materials. Sandbag dikes act as temporary barriers to keep flood waters away from structures. This is a relatively low-cost method, but requires extensive labor. This method also requires advance warning to mobilize personnel to install the sandbags. It is important that the materials be prepared prior to flooding and maintained during the flood event.

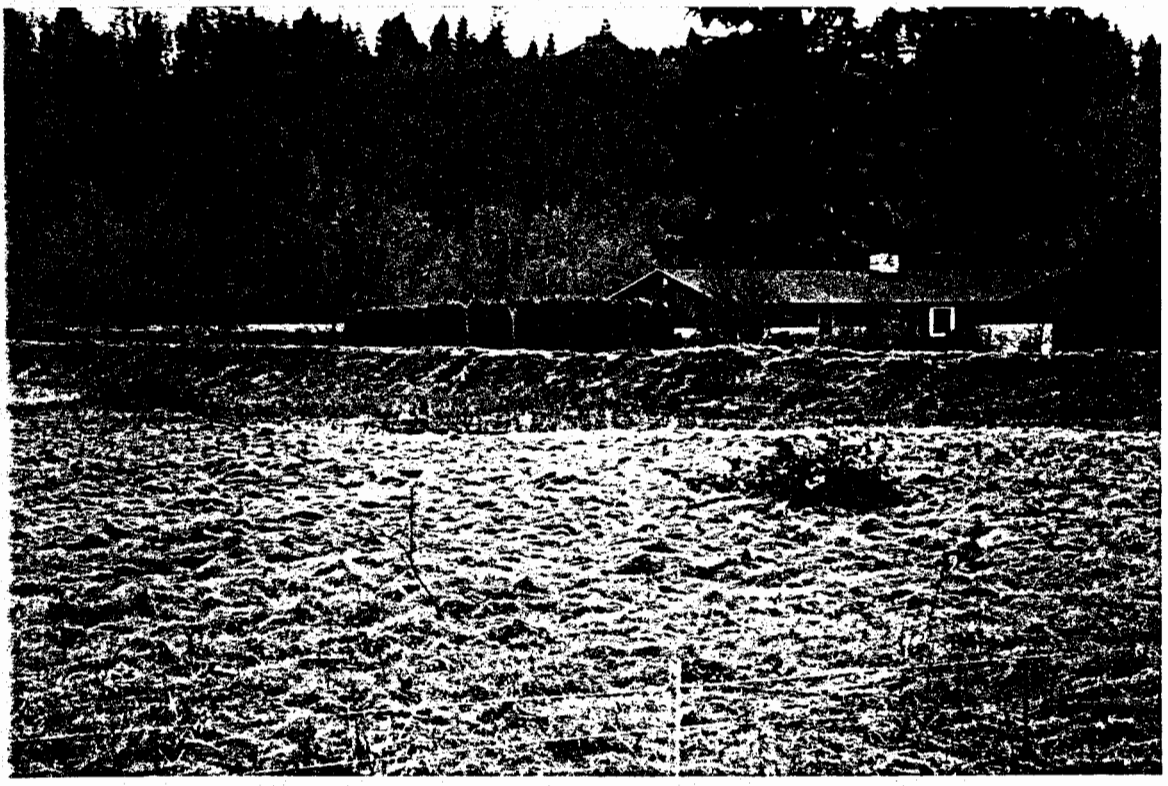
Analysis Approach and Analytical Conclusions

A detailed analysis of flood hazards at all habitable structures in the Valley was completed. Procedures followed and results of this analysis were reported in Issue 6. Part of the development of the flood hazard database involved determining which structures are exposed to high, moderate, or low hazards, and which structures should implement floodproofing projects commensurate with these hazards. The results of the analysis are described in Issue 6.





KCM *1917 First Ave.* *Seattle, Washington 98101*	**Mason County** **SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN**	**Figure 6-22.** **STRUCTURE ELEVATION FLOODPROOFING**



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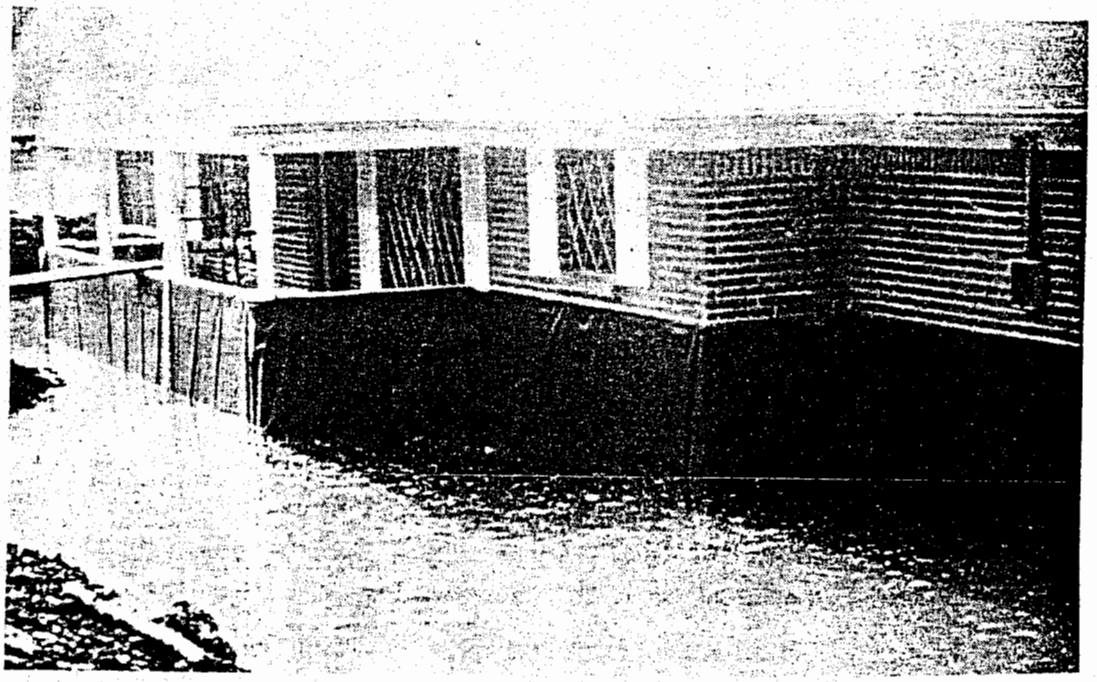
Seattle, Washington 98101

Mason County
SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN

Figure 6-23.
FLOODWALLS AND LEVEES
FLOODPROOFING



KCM *1917 First Ave.* *Seattle, Washington 98101*	**Mason County** **SKOKOMISH RIVER COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN**	Figure 6-24. CLOSURES AND SEALANTS FLOODPROOFING

Recommendations

The following recommendations involve implementation of both alternatives described above:

- The COE should complete the Flood Audit and distribute results to all affected property owners prior to the 1996-97 flood season
- Individual property owners should carefully review floodproofing recommendations resulting from the flood audit, which will be developed specifically for their structures. Property owners should implement floodproofing projects to the extent practicable
- The County should pursue funding through the National Mitigation Fund and other programs to assist local property owners in financing floodproofing projects. Prior to pursuing funding, the county should use information presented in the Flood Audit and the flood hazard analysis in this CFHMP to develop a prioritized program of floodpoofing projects, including projections for total costs of floodproofing all structures in the Valley.

Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Provide information about and promote floodproofing (action).

ISSUE 10: FLOOD WARNING AND EMERGENCY RESPONSE PROGRAM

Residents of the Skokomish River Valley need to know when a flood is occurring or is likely to occur and what its magnitude and duration might be. This information is necessary for residents to take appropriate measures to protect their property and evacuate to safe locations. The following section addresses flood warning and emergency response activities that will help residents and governmental officials achieve that objective. Material is largely based on the 1993 Draft CFHMP, with updates provided as appropriate. An update on actions that have been implemented since issuance of the Draft Plan is presented at the conclusion of this section.

The previous format of issue, alternative, analysis approach, analytical conclusions, and recommended actions was not followed for this section since recommendations were developed directly, without alternatives that were analyzed separately.

Introduction

Three types of flooding can occur in the Valley: a naturally occurring flood, a natural flood combined with a release from the City of Tacoma's two dams on the North Fork (the Cushman dams), and a flood resulting from the failure of the Cushman dams. The potential for dam releases, in addition to naturally occurring unregulated flooding, causes considerable anxiety and uncertainty among residents of the Valley. Recommendations in this section will help

Valley residents and the Skokomish Tribe understand and predict the extent of flooding for each flood situation and make informed decisions on emergency response.

Whenever the Skokomish River starts to rise, residents of the Valley become concerned about whether the river will flood and whether the City of Tacoma Department of Public Utilities Light Division (Tacoma Light Division) will release additional water from its dams, potentially making flooding worse. Two hydroelectric projects, Cushman Dam No. 1 and Cushman Dam No. 2, are operated by the Tacoma Light Division. Cushman Dam No. 1, the larger of the two, impounds Lake Cushman. Cushman Dam No. 2, with a much smaller reservoir, is located about 2.3 miles downstream from Dam No. 1.

The Cushman dams can moderate the effects of floods and under some conditions even prevent flooding. However, at times the utility must release water to ensure safety and prevent overtopping of the dam. The FERC, which licenses hydroelectric projects, requires the Tacoma Light Division to have a plan for notifying people of a release. The FERC also requires an emergency action plan for warning people in the event of the worst possible situation at the dams—a total and instantaneous failure of the dams, causing a sudden, uncontrolled release of all stored water in the two reservoirs. This section discusses notification procedures for releases and for dam failure and recommends improved notification procedures.

On May 20, 1993, a meeting was coordinated by KCM to discuss flood warning and emergency response. The following groups and representatives attended the meeting: Valley residents on the Planning Advisory Committee (PAC), a representative of the Skokomish Tribe, the County public works director, the deputy supervisor of the Cushman dams, and the non-emergency planning coordinator for the Tacoma Light Division, Ms. Dolores Stegeman. Ms. Stegeman described notification procedures that were current at the time.

Notification Procedures for Dam Releases

When the Tacoma Light Division decides to release additional water from the Cushman dams, it is responsible for notifying four entities: the security officer of the Skokomish Tribe, the Mason County 911 dispatcher (Shelcom), the State Emergency Management duty officer, and the Tacoma Light Division's own community and media services. It is the responsibility of the Tribal security officer to notify members of the Tribe, and the responsibility of Shelcom to notify other residents of the Valley and broadcast media. Shelcom uses its Plectron system to send a radio alert to the volunteer fire department in the Skokomish River Valley. The procedures that Tacoma Light Division personnel follow are described in the Division's *Water Release Notification Plan* (the Plan), which is reproduced in Appendix II. The Plan "establishes procedures for the Tacoma Light Division's routine and orderly notification of essential agencies and persons when unusual weather or other conditions require release of water from the utility's hydroelectric dams which could result in greater than normal flows downstream."

The Plan covers the utility's dams on the Nisqually and Cowlitz Rivers as well as Cushman Dam Nos. 1 and 2. Every three months the accuracy of the information in the Plan, such as phone numbers and names of emergency contact persons, is checked. The Tacoma Light Division republishes the Plan at the beginning of each year.

The following section of the Plan describes how the utility monitors weather and reservoir conditions to determine if a release is necessary:

Tacoma's Light Division regularly uses up-to-date weather data and snowpack information in determining the regulation of the reservoirs behind its hydroelectric dams and the discharge of waters past those projects. During unusual weather conditions, Tacoma's Light Division works very closely with the U.S. Geological Survey, the U.S. Army Corps of Engineers, the River Forecast Center and the National Weather Service in assessing potential river conditions which could cause downstream flooding.

Tacoma's Light Division generally endeavors to maximize the flood control capabilities of each of its dams to minimize damage caused by heavy river flows. In addition to reducing a flood crest, or preventing a flood from occurring, the Tacoma Light Division's dams also prevent the trash and debris associated with floodwaters from passing downstream and otherwise adding to the high water damage.

While Tacoma's Light Division can exercise some downstream regulation of those streams flowing into the reservoirs behind its dams at the hydroelectric project sites, it cannot exercise any control over streams emptying into the river systems downstream from these hydroelectric projects. (*Water Release Notification Plan*, p. 2)

As specified in the Plan, when unusual weather conditions persist and it becomes apparent that greater than normal amounts of water must be released to ensure safety and prevent overtopping of the Cushman dams, the Tacoma Light Division makes a series of calls to the four specified entities. Because of the variability of conditions leading to notification, the plan cannot define a set amount of time between first notification and release. A schematic of notification procedures is reproduced in Appendix II and described below.

- The Tacoma Light Division first calls Ed Binder of Tribal Security on the Skokomish Reservation to discuss the amount of release that load dispatchers believe is necessary. Officials of the utility try to agree with the Tribe on the rate of release, but the final decision is made by the utility. The Tacoma Light Division then calls Shelcom, the State Emergency Management duty officer, and the Division's own community and media services. For the most recent release (as of 1993), on January 30, 1992, the Tacoma Light Division made this first round of calls approximately five hours before the release began
- A second round of calls to each of the entities is made when the utility actually starts releasing water from the dam
- The utility makes a third round of calls when the release has reached its planned maximum rate
- The fourth round of calls notifies the entities that the rate of release is being reduced
- The Tacoma Light Division makes a fifth and final round of calls when the release has stopped.

Releases occur infrequently. According to Ms. Stegeman, from 1979 through 1989 there were no releases. Since then there has been one release in each of the years 1990, 1991, and 1992. The utility tries to delay a release until flood waters have begun to recede so that the release does not increase peak high water. It also has a policy of trying to keep the rate of release below 500

cubic feet per second (cfs), and will not release in excess of 2,000 cfs. To accomplish the release, workers open the spill gates. A worker is stationed at the dams on standby for 24 hours a day for the duration of the release. During the August 29-September 1, 1991, release, the Cushman Dam No. 2 release traveled through the North Fork in approximately 3 hours. The travel time for the release to reach the US 101 bridge, 12 miles downstream from Cushman Dam No. 2, was approximately 6 hours. This release was necessary because of the unusual storm August 28-30, 1991, measuring 8.28 inches of precipitation at the Staircase Rapids gauge. The utility tries to time a release so that the additional water does not add to the river volume during high tide. However, that was not possible during the August 1991 storm, when the release was constant for two and one-half days. (See Chapter 4 for information on December 1994 release.)

Concerns of Residents About Releases

At the May 20, 1993, meeting, residents expressed the following concerns:

- Residents do not always get messages from Shelcom. The utility calls Shelcom, and Shelcom notifies the Valley's volunteer fire district by radio, but there is a problem with notification being forwarded to residents in the Valley.
- People may be on the river or along its banks. How will they be notified of a release?
- Something went wrong during a previous release and some residents reported that a two-foot high "slug" of water came down. Residents need some assurance that this will not happen again.
- When the river is rising due to natural flood conditions, residents may wonder whether the utility is going to release additional water. There is a need for "peace of mind" about the probability of such a release.
- There is a need to know what effect various flood stages will have on the Valley. What roads and property will be flooded and by how much? What additional effect will a release have on flooding? Will the release be coordinated with the tide so that it does not exacerbate the effect of high tide?

Recommendations for Notification of Releases

The following recommendations are based on a review of existing procedures for dam releases and the concerns of Valley residents:

Make it easier for residents and the Tribe to obtain information about flood conditions directly. Obtain access for the Skokomish Tribe and the Skokomish River Flood Control District to U.S. Geological Survey (USGS) gauge data.

The USGS currently has gauging stations on the Skokomish River at the following locations:

- North Fork Skokomish River below Cushman Dam, #120588, 1.2 miles downstream of Cushman Dam No. 2

- North Fork Skokomish River near Potlatch, #120595, 7.2 miles downstream of Cushman Dam No. 2 and about 1.1 miles upstream of the confluence with the South Fork
- Skokomish River near Potlatch, #120615, at the US 101 bridge.

The stations on the North Fork below Cushman Dam and on the mainstem at US 101 transmit data every 15 minutes to the USGS Field Office in Tacoma; the station on the North Fork, 7.2 miles downstream from Cushman Dam No. 2, will have telemetric capability soon. The Tacoma Light Division has access to this information through a computer link-up. The Skokomish River Flood Control District and the Skokomish Tribe should get access to and learn how to use information from the USGS gauges. This will allow Valley residents to be proactive in their monitoring of river levels and enable residents to make emergency response decisions based on their analysis of river conditions.

The following is a step-by-step approach to obtaining river data:

a. The residents should identify a location (for example, the fire house or school) to serve as a control center during flood conditions, and designate a contact person responsible for contact with the Tacoma Light Division's Energy Control Center.

b. The Skokomish River FCZD and the Skokomish Tribe should obtain access to the river level data from the USGS. The contact person with the USGS is William Wiggins, Tacoma Field Office, 593-6510, extension 122. The Tacoma Light Division should facilitate this process to ensure that river data are available to Valley residents during flood events.

c. The FCZD and the Skokomish Tribe should obtain equipment that will enable the FCZD to receive a printout of river levels in its flood control center. The necessary equipment includes a computer, a modem for connecting the computer with the USGS, and a printer for listing river levels and flows. The phone company can connect the computer and modem to the USGS computer. The FCZD and the Skokomish Tribe should also have a cellular phone in case telephone lines are down during a flood.

d. Once the equipment is installed, the FCZD and the Skokomish Tribe can call the USGS 24 hours a day and connect their computer with the USGS via a modem to obtain information about river levels. The USGS 15-minute readings are compiled each hour, so the FCZD and the Tribe can receive river level and flow data at each station within an hour of real time. This will enable residents to monitor river levels as floods occur.

Provide information directly to Valley residents about releases

The FCZD should identify a person to be notified in the event of a release from the Cushman dams. The FCZD should also identify an alternate so that 24-hour-a-day, 365-day-a-year notification is assured. The Tacoma Light Division should add the FCZD contact person and alternate, when they are designated, to the list of those it notifies when it conducts a release from the Cushman dams.

The Skokomish River FCZD and the Skokomish Tribe should be able to telephone the Tacoma Light Division's load dispatchers whenever residents are concerned about a possible release. For example, if the river level is rising, rather than waiting for a call from Tacoma Light Division personnel, the Tribal security officer and the FCZD's designated contact person should be able to ask the utility directly whether a release is likely. Communication between the Tacoma Light Division and the FCZD and Tribe is also important so that residents can benefit from the utility's perspective and current thinking about flood conditions and the need for a release. The telephone number for the load dispatcher in Tacoma at the Energy Control Center is 383-5271, extension 8401. There is also an 800 number: (800) 752-6745, extension 8402.

Residents of the Valley need to establish a procedure for notifying residents of the Valley. The Tacoma Light Division's responsibility is to notify the Tribal security officer, Shelcom, the State Emergency Management duty officer, the Tacoma Light Division's own media services, and the FCZD contact person, once that person is designated. It will be up to the FCZD and the Volunteer Fire Department to decide how to notify other residents of the Valley.

Install a gauge on the South Fork

The South Fork contributes about half the flow to the Skokomish River. Currently, a rough estimate of the flow in the South Fork can be calculated by subtracting the river flow measurement at the gauge just below the No. 2 Dam on the North Fork from the river flow at the US 101 bridge gauge on the mainstem of the Skokomish River. In 1993, the North Fork near Potlatch gauge, located 7.2 miles downstream from Cushman Dam No. 2, was equipped with the capability to transmit data to the USGS computers in Tacoma. This will improve the estimate of the South Fork flow.

While the process of subtracting the North Fork flow from the mainstem flow at US 101 provides a rough estimate of flow in the South Fork, a better approach is to measure flow in the South Fork directly. During the dam release of August 29 to September 1, 1991, the Tacoma Light Division estimated the travel time from the North and South Fork confluence to US 101 to be about three hours. Therefore, available flow data on the North Fork and the mainstem will be out of phase and their difference may not represent the flood contribution from the South Fork.

The potential for dam releases, in addition to naturally occurring unregulated floods, causes considerable anxiety and uncertainty among Valley residents. Therefore, the best available flow data from both the North and South Forks is needed for residents to make informed decisions on emergency response to flood events. The USGS established a gauge in 1931 on the South Fork, approximately 3.2 miles upstream from the confluence with the North Fork. However, this gauge has not been operational since 1984. The FCZD and the Tribe should request that FERC require the reestablishment of the South Fork gauge with a telemetric capability similar to the North Fork and mainstem gauges.

Notification Procedures for Failure of the Dams

The Tacoma Light Division has an *Emergency Action Plan for Cushman Hydroelectric Project FERC Project No. 460.* The Emergency Action Plan (EAP), like the release plan, is checked every three months for accuracy of contact persons, phone numbers, and procedures, and is republished at

the beginning of each year. A copy is included in Appendix JJ. The FERC requires that every hydroelectric facility have an emergency action plan that addresses the worst possible event.

For concrete dams such as the Cushman Dam Nos. 1 and 2, the worst event is considered to be a complete and instantaneous or rapid failure. The EAP lists earthquake, rapid foundation failure, and nuclear bombing as possible causes of a dam failure. Appendix B of the EAP contains the "Failure Mode and Flood Analysis Study" for the failure of both dams and for the individual failure of Cushman Dam No. 2. A failure of Cushman Dam No. 1 alone was not analyzed because the magnitude of a failure of the upstream Dam No. 1 was judged to be enough to cause the failure of Dam No. 2. A failure of both dams would cause a flood with a peak of about 1.2 million cfs in the Skokomish River, filling the Valley between the North and South Fork confluence and US 101 to a depth of about 40 feet. A summary of peak flows and time from dam break to flooding for selected locations is included in Table 6-21 for a failure of Cushman Dam Nos. 1 and 2.

TABLE 6-21.
FLOOD CONDITIONS ASSOCIATED WITH DAM BREAK
OF CUSHMAN DAMS NOS. 1 AND 2

	Time from dam break to start of flooding (hrs)	Time from dam break to maximum flooding (hrs)	Maximum Skokomish River flow (cfs)	Approximate maximum depth of flooding (ft)
Near confluence of North and South Forks	0.8	1.9	1.35 million	47
Skokomish River at US 101 Bridge	1.6	3.1	1.15 million	40
Skokomish River at Hood Canal	2.6	3.8	1.03 million	8

A failure of just Cushman Dam No. 2, which holds back a much smaller reservoir than Dam No. 1, would cause about 3 feet of water in the Valley between the North and South Fork confluence and US 101. This would not have the catastrophic consequences of a two-dam failure. A summary of peak flows and time from dam break to flooding for failure of Cushman Dam No. 2 is included in Table 6-22.

The EAP describes preventive actions and the sensing devices that continually monitor the condition of each dam and the automatic alarm systems that signal an emergency. Cushman No. 1 powerhouse, which is located at the dam site, is manned 24 hours per day. Cushman No. 2 powerhouse is remotely controlled from Energy Control Center in Tacoma. Remote sensing and telemetry equipment allow the Tacoma Power Dispatcher to monitor and regulate generation. Maintenance personnel are at the sites during the normal week-day work schedule. The Cushman project manager lives in the immediate vicinity and oversees daily visual inspections. He or a designee is available 24 hours per day if needed (EAP p. IV-1).

The EAP prepares for two failure scenarios: failure is imminent or has occurred, or a potentially hazardous situation is developing. The EAP specifies notification procedures for either type of failure at each dam.

TABLE 6-22.
FLOOD CONDITIONS ASSOCIATED WITH DAM BREAK
OF CUSHMAN DAM NO. 2

	Time from dam break to start of flooding (hrs)	Time from dam break to maximum flooding (hrs)	Maximum Skokomish River flow (cfs)	Approximate maximum depth of flooding (ft)
Near confluence of North and South Forks	1.0	1.6	97,000	3.0
Skokomish River at Highway 101 Bridge	4.0	5.0	31,000	1.0
Skokomish River at Hood Canal	no flooding	no flooding	21,000	0.0

Failure is Imminent or Has Occurred at Cushman Dam No. 1

If failure is imminent or has occurred at Cushman Dam No. 1, the EAP instructs the Cushman Dam No. 1 operator to evacuate the powerhouse, move to the station house at the top of the tram, and notify the load dispatcher and the Cushman project manager. The load dispatcher then notifies Shelcom by telephone or VHF two-way radio, the Washington State Emergency Management duty officer, the National Weather Service, and the Tacoma Light Division's assistant power manager. Shelcom in turn notifies the Valley's volunteer fire department by radio.

Dam-Failure Emergency Alarm Sounds for Cushman Dam No. 2

If the dam-failure emergency alarm for Cushman Dam No. 2 rings in the Tacoma Energy Control Center, the EAP instructs the load dispatcher to confirm the dam failure by checking for loss of monitoring data or other alarm conditions from the powerhouse. The load dispatcher then notifies the Cushman Dam No. 1 operator, the Cushman project manager, Shelcom, the Washington State Emergency Management duty officer, the National Weather Service, and the Tacoma Light Division's assistant power manager. Shelcom in turn notifies the Valley's volunteer fire department by radio.

Potentially Hazardous Situation at Cushman Dam No. 1

If a potentially hazardous situation is developing at Cushman Dam No. 1, the EAP instructs the Cushman Dam No. 1 operator to notify the load dispatcher and the Cushman project manager. The load dispatcher is instructed to notify the Shelcom dispatcher and the Tacoma Light Division's assistant power manager, immediately and in that order. Shelcom notifies the Valley's volunteer fire department by radio.

Potentially Hazardous Condition Alarm Sounds at Cushman Dam No. 2

If the load dispatcher receives notification of a potentially hazardous dam condition alarm indicating a slowly developing failure at Cushman Dam No. 2, the EAP instructs the load

dispatcher to verify the information received before proceeding with notification. The load dispatcher then notifies the Cushman Dam No. 1 operator, the Cushman project manager, the Shelcom dispatcher, and the Tacoma Light Division's assistant power manager. The Shelcom dispatcher notifies the Valley's volunteer fire department by radio.

Concerns of Residents About Dam Failure

The chief concern is that residents of the Valley be notified quickly enough to evacuate the Valley is a failure is imminent or has already occurred. As shown in Table 6-21, for the worst case of failure of Cushman Dam Nos. 1 and 2, travel time for the flood wave ranges from about 0.8 hour at the North and South Fork confluence to 2.6 hours at Hood Canal. Therefore, for a warning system to be effective for dam failures, it must be operable immediately following the dam break. Without immediate warning, loss of life in the Valley would be inevitable.

Recommendations for Notification in Event of Dam Failure

Establish a more direct way to warn residents

Several methods for more direct warning of residents are as follows:

- Sirens: Sirens can provide immediate warning of a dam break. However, there is a concern that if the sirens were to sound, many people in the Valley might not know what they were for. Therefore, a siren system would have to be supported by signage with instructions to evacuate the Valley immediately. The siren system should also be tested periodically. Such testing would need to be well-publicized so that Valley residents would not become alarmed and so that they could learn to recognize the sound and purpose of the siren.
- Speakers: The Tacoma Light Division reports that its experience with outdoor speakers to transmit verbal warnings has shown them to be ineffective, mostly because the warnings are difficult to understand.
- Computerized, telephonic alert notification systems: According to Jimmy Holcut of the Washington State Emergency Management Office, several software systems on the market can program the public telephone switch systems to call pre-programmed numbers and deliver a message. Telephones can be dialed sequentially, or, in some cases, simultaneously. Simultaneous transmissions depend on the switching and trunk line capabilities of the telephone company's system. According to Mr. Holcut, such systems can cost $20,000 to $50,000, which can be less expensive than sirens. These systems can keep dialing a number until someone answers, and can print out a record showing whether the message was received for each number. Residents receiving the message would get a verbal warning rather than a loud noise, as with a siren. US West has investigated this option for the Skokomish River Valley, and concluded that it is not feasible at the present time.
- Alarm devices in each household: According to Dale Fultz, chairman of the Emergency Broadcast Plan for Puget Sound, there is no such alarm system on the market. Several federal agencies, including the Department of Defense and the FEMA, are now working on this procedure. To date, they have concluded

that people probably would not purchase a separate alarm device, that public switching systems cannot be relied on in an emergency, and that the emphasis should be on building a device into new radios and televisions that would automatically switch them on in an emergency. Once on, they would interrupt local programming and broadcast an emergency message.

- Use of local radio and television stations: KMAS of Shelton is the designated Emergency Broadcast Station for Mason County. Residents also listen to KGY in Olympia, and to Seattle and Tacoma radio and television stations. If a dam failure is imminent or has already occurred, all such stations should be notified to immediately issue an evacuation warning. Any such notification procedure involving public broadcasters should be routed through the Mason County Sheriff and Shelcom.

Given the rapid travel time of a flood wave following a dam break, and the extreme magnitude of the flood, a warning system in the Valley is needed even for the remote possibility of a dam break occurring. Based on the notification possibilities noted above for a dam break scenario, sirens in combination with the use of radio and television stations appears to be the most effective method currently available.

Contact Skokomish tribe and Skokomish River FCZD

The Skokomish Tribal Security Officer and a contact person for the Skokomish River FCZD should be added to the list of entities that the Tacoma Light Division's load dispatcher is instructed to notify immediately.

The FCZD and the Skokomish Tribe should request FERC to require a warning system for dam failure. Without an immediate warning system, there would certainly be considerable loss of life in the Valley following a worst-case scenario of failure of Cushman Dam Nos. 1 and 2.

Update on Actions Implemented Since 1993 Draft CFHMP

Following completion of the 1993 Draft CFHMP, several enhancements to the flood warning and emergency response program were implemented. A new automated telephone notification system was acquired and the gauging station network was upgraded.

A telephone notification system was acquired by Mason County Emergency Services in the spring of 1995. The system is designed to notify citizens of natural or technological disasters, including flood events. The system contains a database of telephone numbers of Mason County businesses and residents. During an emergency, the system automatically dials phone numbers in the database and provides a recorded public notice. Residents were notified about the system in August 1995 and given the opportunity to register by mail. Questions relating to the system can be directed to the Director of the Mason County Department of Emergency Services, (360) 427-9670, ext 329.

The following gauging station improvements were implemented by the USGS since completion of the 1993 Draft Plan (Peck, B., 14 March 1996, personal communication):

- North Fork Skokomish near Potlatch (Station 12059500) - Satellite telemetry was added to this established station. The station is currently on "ALERT" mode, whereby data are collected every 15 minutes and transmitted every 4 hours until the river reaches a predefined flood stage. After the river rises above flood stage, data are collected and sent approximately every 5 minutes.
- South Fork Skokomish River near Union (Station 12060500) - This station was reestablished in October, 1995. It now operates on year-round basis, transmits data using satellite telemetry, and is set on ALERT mode
- Skokomish River near Potlatch (Station 12061500) - This station already has satellite telemetry. A telephone modem was installed for Mason County in December 1995 to provide redundancy in data transmissions and to allow the County to have direct access to real-time gauge data. Current problems of silt covering the river intake will necessitate reconfiguration of the gauge with pressure transducers at some future time.
- Vance Creek - Unsuccessful attempts were made to install a staff gauge adjacent to the Vance Creek bridge at the end of the Skokomish Valley Road. Investigation of other locations for establishment of a gauging station are being considered by the USGS.

Key Elements

The following key elements are addressed either through preparation of the material in this section or future implementation of the recommended actions.

- Promote programs and strategies to reduce the risk of flood damage to life, health, and property for all citizens of the Skokomish Valley (objective).
- Recommend and seek funding for emergency warning and evacuation equipment and procedures in conjunction with existing efforts by the local fire district and the Mason County Department of Emergency Services (action).

CHAPTER 7.
FUNDING

One of the greatest challenges that confronts any jurisdiction once it has completed a comprehensive plan is to find the resources to implement that plan. This is especially true in rural counties, such as Mason County, where available revenues may fall short of the cost of proposed solutions. Many of the recommendations contained within this CFHMP will require expenditures well beyond what the County could afford without some form of assistance.

This chapter describes potential funding sources that should be considered for assistance in completing projects recommended in this CFHMP. Sections on the State Hazard Mitigation Grant Program, Reigle Community Development and Regulatory Improvement Act, and Robert T. Stafford Relief and Emergency Assistance Act, presented in Chapter 5, are included here for completeness. Table 7-1 summarizes funding options described in this chapter.

ASSISTANCE FROM UPPER WATERSHED CONTRIBUTORS

Previous sections of this CFHMP have documented that the conveyance capacity of the Skokomish River has diminished over the last several decades. Much of the available evidence indicates that this decrease in conveyance capacity is related to resource development activities undertaken by groups involved in upper Skokomish Watershed projects.

Cushman Project

Given the link between Cushman project water diversions and flooding conditions in the Skokomish Valley, the City of Tacoma should be considered as a potential partner for providing funding and resources for implementing flood control and flood hazard management projects recommended in this CFHMP.

One of the alternatives presented in the Draft CFHMP specifically includes provisions for participation by Tacoma in implementation of flood hazard management projects. Alternative 3, the staff recommendation, includes the following provisions for mitigating environmental impacts on channel morphometry:

> Under this alternative, Tacoma would consult with the Tribe, EPA, [COE], [Ecology], WDFW, Mason County, and FEMA to identify cost-effective measures to increase the Skokomish River's conveyance capacity and thereby reduce the human health and welfare risks from flooding. Within 1 year of license issuance, Tacoma would submit to the Commission a final channel conveyance capacity enhancement plan including: recommended measures to reduce flood hazards to an acceptable level, cost estimates for the selected measures, options for financing the project(s) including Tacoma's proposed level of contribution, and any comments on the report from plan participants (KCM 1993).

Timber Interests

The South Fork Skokomish watershed has been heavily logged over the last several decades. Evidence suggests that logging practices have increased sediment inputs to the mainstem (see Chapter 6, Issue 1, and Appendix E). The primary groups involved in logging in the South

TABLE 7-1
FUNDING SOURCES FOR IMPLEMENTATION OF THE CFHMP

Funding Source	Program	Administering Agency	Eligible Projects	Maximum Award	Local Match	Percent Interest
Upper Watershed Contributors	Cushman Project, Timber Interests	N/A	Projects and plans relating to flood control and flood hazard management	N/A	N/A	N/A
Flood Control Assistance Account Program	Grant	Ecology	Projects and plans relating to flood control and flood hazard management	$500,000	25%—comprehensive plans, 50%—projects, 20%—emergency projects	N/A
Centennial Clean Water Fund	Grants and loans	Ecology	Projects and activities that result in water quality benefits	$2.5 million for facilities, $250,000 for activities	50%—facilities, 25%—activities	0-5 years @ 0%, 6-14 years @ 60% of market, 15-20 years @ 75% of market
State Water Pollution Control Revolving Fund	Loan	Ecology	Projects and activities that result in water quality benefits		N/A	0-5 years @ discretion of Ecology, 6-14 years @ 60% of bond buyer's index, 15-20% @ 75% of bond buyer's index
State Hazard Mitigation Program	Grant	CTED	Flood hazard mitigation	Variable	12.5%	N/A
Reigle Act	Grant	FEMA	Flood hazard mitigation	Variable	25%	N/A
Stafford Act	Grant	FEMA	Flood disaster relief and emergency assistance	Variable	25%	N/A
Small Flood Control Projects	Grant	COE	Flood control projects		25-50%—construction, 100%—maintenance	N/A
Emergency Bank Protection	Grant	COE	Streambank protection	$500,000	25%	N/A
Channel Clearing for Waterways	Grant	COE	Removal of obstructions	$1 million nationwide	10-50%	N/A
Snagging & Clearing for Flood Control	Grant	COE	Removal of snags and debris	$500,000	10-50%	N/A
Planning Assistance to the States	Grant	COE	Preparation of plans and studies relating to flood control		50%	N/A
Flood Control Zone District	Taxing authority	County Commissioners	General flood control projects and activities	Based on annual levies	N/A	N/A
Drainage District, Diking District, etc.	Taxing authority	District Commissioners	General flood control projects and activities	Based on annual levies	N/A	N/A
City of Tacoma	Municipal	City of Tacoma	General watershed activities	N/A	N/A	N/A

Fork watershed have been the USFS and Simpson Timber Company; both are nearing completion of watershed analyses in the South Fork, with plans for road maintenance in the watershed to prevent future erosion also in various stages of implementation.

As there is a connection between increased sediment inputs to the mainstem, riverbed aggradation, and increased flooding in the Valley, it is recommended that logging interests in the upper watershed be considered as potential partners for providing funds and resources to implement flood hazard management projects recommended in this CFHMP.

ASSISTANCE FROM THE STATE GOVERNMENT

Centennial Clean Water Fund

The Centennial Clean Water Fund (CCWF) is both a grant and a loan program. CCWF-approved projects must be for the planning, design, acquisition, construction, and improvement of water pollution control facilities and activities. Flood control projects are typically not eligible for CCWF funds. However, if a water quality benefit can be demonstrated as a result of a flood control project, CCWF funds can be made available. There are several types of projects in the CFHMP that could result in water quality benefits, so the CCWF should be considered as a potential source of funding. A total of $2.5 million is available per funding cycle for facilities, with $250,000 available for activities under the CCWF.

The CCWF grants program will fund a maximum of five projects per year, no more than two of which can be for facilities. The CCWF requires a 50 percent local match for facilities and a 75 percent local match for activities. The local share may come from any combination of cash, other grants, or loans. In-kind contributions may be used for activities projects only.

The CCWF loan program will issue loans at the following interest rates: 0 to 5 years, 0 percent interest; 6 to 14 years, 60 percent of market rates; 15 to 20 years, 75 percent of market rates.

State Water Pollution Control Revolving Fund

Like the CCWF, the State Revolving Fund (SRF) finances planning, design and construction of facilities and the planning and implementation of activities that address water quality problems or water pollution prevention. Again, while the SRF is designed to provide assistance for water pollution control efforts, some flood control projects that will result in water quality benefits may be considered.

SRF loans may be used for up to 100 percent of a project's cost. SRF loans may also be used to provide a match for CCWF grants, with some restrictions.

The following interest rates apply to SRF loans: 0 to 5 years, discretion of Ecology; 6 to 14 years, 60 percent of the bond buyer's index for municipal bonds; 15 to 20 years, 75 percent of the bond buyer's index for municipal bonds.

Flood Control Assistance Account Program

The Flood Control Assistance Account Program (FCAAP) is by far the most widely used source of grant funding for floodplain activities that help reduce flood hazards and flood damage.

Eligibility for FCAAP funds is determined by Ecology. Before FCAAP funds can be used to implement flood hazard management projects, a CFHMP must be completed. In addition, the municipality seeking FCAAP funds must be a participant in the National Flood Insurance Program (NFIP).

FCAAP funds are allocated to counties for each fiscal biennium, beginning July 1 of odd-numbered years. From a potential total state allocation of $4 million in the program, a maximum of $500,000 can be granted to a single county.

The percentage of the local match is determined by the type of project being funded. FCAAP funds 75 percent of the cost of CFHMPs and 50 percent of the cost of projects that preserve or restore natural conditions, or restore or enhance facilities or structures. Any maintenance projects applied for must be consistent with the approved CFHMP.

Ecology also makes a limited amount of money available for emergency flood-related projects. To be eligible for the emergency funds an emergency must be declared by the local government and the work must be approved by Ecology. The work undertaken through the emergency grant must be to immediately protect lives and property. FCAAP will fund 80 percent of the cost of emergency-grant-funded projects.

FCAAP funds may also be used for funding the non-federal share of COE studies.

State Hazard Mitigation Program

The Emergency Management section of the State Military Department coordinates state disaster mitigation, preparedness, response, and recovery activities. Under this mandate, the agency administers the State Hazard Mitigation Grant Program (also called the 404 program after the section of the Stafford Act dealing with hazard mitigation), authorized and partially funded under the Stafford Act. State Hazard Mitigation Grants are made to local governments on a cost-share basis, with the federal, state, and local percentage matches set at 75, 12.5, and 12.5 percent, respectively. Federal funding for this program requires a Presidential declaration of disaster. State and federal money distributed under this program can be used only for acquisition of property, demolition or elevation of structures, or relocation of residents.

Funding for the program since 1989 has totaled approximately $9 million, with approximately $6 million coming from the federal government and $3 million from state sources. The State has established a competitive procedure for funding. Applications are reviewed by a panel of state and local officials and scored on how well they meet the specific terms and conditions required by the Stafford Act. This process is administered by CTED. Selected applications are then sent to FEMA for approval.

ASSISTANCE FROM THE FEDERAL GOVERNMENT

Grants and Assistance Provided by FEMA

Reigle Community Development and Regulatory Improvement Act

Title V of the Reigle Community Development and Regulatory Improvement Act of 1994 (Public Law 103-325) is referred to as the National Flood Insurance Reform Act of 1994. One of

the provisions of the act is the establishment of a program to provide financial assistance to states and communities for planning and implementating flood mitigation activities. Details on the program are contained under Subtitle D—Mitigation of Flood Risks.

A National Flood Mitigation Fund is set up through the act to fund flood mitigation planning and implementation activities. Money for this fund comes from the National Flood Insurance Fund. The total amounts to be credited to the new mitigation fund are as follows:

- $10,000,000 in the fiscal year ending September 30, 1994
- $15,000,000 in the fiscal year ending September 30, 1995
- $20,000,000 in the fiscal year ending September 30, 1996
- $20,000,000 in each fiscal year thereafter.

To be eligible for funding for activities, the state or community must have a flood risk mitigation plan that accomplishes the following:

- Describes the activities to be funded
- Is consistent with specific criteria contained in section 1361 of the National Flood Insurance Act of 1968 (*Criteria for Land Management and Use*)
- Provides protection to structures covered by an existing flood insurance policy.
- Is approved by the Director
- Includes a comprehensive strategy for mitigation activities for areas affected by the plan
- Has been adopted by the State or the community following a public hearing.

Funding can be used only for activities included in the approved plan. Activities must be technically feasible, cost-effective, and cost-beneficial to the National Mitigation Fund. Mitigation activities for repetitive-loss structures and structures that have incurred substantial damage will receive higher priority.

There are different funding limits for planning and implementation activities under the act. These are described below. Both categories of grants are provided on a 75 to 25 percent federal to local cost-share basis. The act lists the following specific activities as eligible for funding:

- Demolition or relocation of any structure located on land along the shore of a lake or other body of water certified by an appropriate State or local land use authority to be subject to imminent collapse or subsidence as a result of erosion or flooding
- Elevation, relocation, demolition, or floodproofing of structures (including public structures) located in areas having special flood hazards or other areas of flood risk
- Acquisition by States and communities of property (including public property) located in areas having special flood hazards or in other areas of flood risk, and property substantially damaged by flood, for public use, as the Director determines is consistent with sound land management and use in such an area

- Minor physical mitigation efforts that do not duplicate the flood prevention activities of other federal agencies and that lessen the frequency and severity of flooding and decrease predicted flood damage, not including major flood control projects such as dikes, levees, seawalls, groins, and jetties unless the Director specifically determines in approving a mitigation plan that such activities are the most cost-effective mitigation activities for the National Flood Mitigation Fund
- Beach nourishment activities
- The provision of technical assistance by States to communities and individuals to conduct eligible mitigation activities
- Other activities that the Director considers appropriate and specifies in regulation
- Other mitigation activities not described above that are described in the mitigation plan of a State or community.

Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288)

The Robert T. Stafford Disaster Relief and Emergency Assistance Act (The Stafford Act) provides assistance following Presidential declarations of major disasters. Title IV presents details on major disaster assistance programs, including provisions for property acquisition and relocation assistance. Cost-sharing is available for up to 75 percent of the cost of any hazard mitigation measures that the President has determined are cost-effective and which substantially reduce the risk of future damage, hardship, loss, or suffering in any area affected by a major disaster. However, the total amount of mitigation funding under any disaster declaration cannot exceed 15 percent of the total grant funds provided for the disaster.

The specific terms and conditions used to determine if an acquisition or relocation project is eligible to receive federal funding under the Stafford Act are as follows:

- Acquisition and relocation projects funded under this act must be cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering in any area affected by a major disaster
- Acquisition and relocation projects and all other mitigation measures must be identified based on an evaluation of natural hazards
- The applicant (the county or the state) must complete an agreement stating that:
  - The property will be dedicated and maintained in perpetuity for a use that is compatible with open space, recreational, or wetlands management practices
  - The only new structures erected on the property will be public facilities open on all sides and functionally related to a designated open space, rest rooms, or structures approved by the Director in writing before the start of construction

— No application will be made for additional disaster assistance for projects relating to the property and no federal funding will be granted for such projects.

Grants and Assistance Provided by the COE

The COE has a variety of programs to provide assistance for planning and implementation of flood hazard management projects.

Small Flood Control Projects

Section 205 of the 1948 Flood Control Act authorizes construction of small flood control projects, including levees, channel enlargement, realignments, obstruction removal, and bank stabilization. An important proviso attached to this assistance is that each project must be a complete solution to the problem and must not commit the federal government to additional improvements to insure effective operation.

Local government is responsible for 25 to 50 percent of the costs of the project and 100 percent of all future maintenance and operation costs.

Small Navigation Projects

Section 107 of the 1960 River and Harbor Act authorizes construction of small navigation projects, including the creation of channels and the snagging and clearing of debris.

Each project must be sponsored by and coordinated with local interests. Local government is responsible for 10 to 50 percent of the cost, depending on the depth of the navigation project.

Emergency Bank Protection

Section 14 of the 1946 Flood Control Act provides for emergency streambank protection to prevent damage to highways, bridge approaches, municipal water supply systems, sewage disposal plants, and other essential public works facilities. Churches, hospitals, schools, and nonprofit public facilities may also benefit from work done under this program. Projects cannot be done soley to protect privately owned properties or structures. Again, each project must constitute a complete solution to the problem involved and must not commit the federal government to additional improvements to insure effective project operation.

Local government is responsible for at least 25 percent of the project cost. The maximum amount that the COE can spend in a single year in any one locality is $500,000.

Channel Clearing for Navigation

Section 3 of the River and Harbor Act of 1945 authorizes the COE to remove unreasonable obstructions in navigable portions of rivers, harbors, waterways and tributaries, in order to provide existing boat traffic with safe unobstructed passage. The applicability of this program to the Skokomish River is unclear. Currently, the Skokomish River is considered a navigable body of water, though it receives little no boat traffic.

The COE may spend $1 million annually throughout the nation. The local government share ranges from 10 to 50 percent of the cost, depending on the scope of the project.

Snagging and Clearing for Flood Control

Section 208 of the 1954 Flood Control Act allows for the removal of accumulated snags and other debris and for channel clearing and straightening in navigable streams and tributaries. Again, each project must be a complete solution to the problem.

The COE may spend $500,000 annually in a locality. The local government share ranges from 10 to 50 percent of the cost, depending on the scope of the project.

Floodplain Management Services

Section 206 of the Flood Control Act of 1960 authorizes the COE to provide information, technical assistance, and guidance to city, county, state and federal agencies. Examples of the types of informational assistance provided through this program are data on flood sources and types, obstructions to flood flows, flood depths or stages, flood water velocities, flood warning and preparedness, flood damage reduction studies and audits, and floodproofing.

While the Corps provides study findings and pamphlets to its customers free of charge, all costs for services must be reimbursed according to a set fee schedule. Other grant funds may be used to pay for these services wholly or in part.

Planning Assistance to the States

Section 22 of the Water Resources Development Act allows the COE to assist local governments in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. This program may encompass many types of studies, including water quality, habitat improvement, hydropower development, flood control, erosion, and navigation. Studies are typically at a planning level and do not include design for project construction.

Costs for projects undertaken under this program require a 50 percent local match. The local match can be met either wholly or in part with other non-federal grant funds.

INCREASED FUNDING THROUGH SPECIAL PURPOSE DISTRICTS

In addition to grants and loans, a reliable, continuing source of revenues is needed to implement and maintain the projects that are recommended in this CFHMP. In 1976 Mason County created an FCZD (Resolution Nos. 632 and 639, July 28, 1976, and August 23, 1976) (see Chapter 2). FCZDs constitute quasi-municipal corporations with the authority to levy taxes under powers granted to a taxing authority (Article VII, section 1) and a taxing district (Article VII, Section 2) in the State Constitution.

Mason County's FCZD currently taxes all properties within its boundaries at $.50 per $1,000 of assessed value. In 1996 the total assessed value of properties in the FCZD is $68,706,166. The amount of tax revenue that will come to the FCZD for 1996 is $34,353.08.

Assuming annual revenues of approximately $34,000, the FCZD is not currently producing enough revenue to afford even the maintenance costs of many of the projects recommended in this CFHMP, let alone costs for design, construction and repair.

The problem of insufficient revenue is exacerbated by the fact that the regular levy rate of $.50 per $1,000 of assessed value is subject to an early proration. The FCZD overlaps several other districts, such as school districts, fire districts, hospital districts, etc. The FCZD is subject to a total district budget of $5.90. If the sum of the levy rates of all districts is greater than $5.90, the levy rates of the districts are prorated so that the sum is lowered to $5.90. The FCZD is one of the first districts to be prorated, and in 1995 the levy rate after proration was approximately $.25 per $1,000 of assessed value, for a total levy revenue of approximately $16,000.

This CFHMP recommends that Mason County explore two options to increase revenues.

Excess Levies, Assessments, and Charges

FCZDs have the following revenue options under Chapter 86.15 RCW:

> **86.15.160 Excess levies, assessments, and charges--Local improvement districts.** For the purposes of this chapter the supervisors may authorize: (1) An annual excess ad valorem tax levy within any zone or participating zones when authorized by the voters of the zone or participating zones under RCW 84.52.052 and 84.52.054;
>
> (2) An assessment upon property, including state property, specially benefited by flood control improvements or storm water control improvements imposed under chapter 86.09 RCW;
>
> (3) Within any One or participating zones an annual ad valorem property tax levy of not to exceed fifty cents per thousand dollars of assessed value when the levy will not take dollar rates that other taxing districts may lawfully claim and that will not cause the combined levies to exceed the constitutional and/or statutory limitations, and the additional levy, or any portion thereof, may also be made when dollar rates of other taxing units is released therefor by agreement with the other taxing units from their authorized levies under chapter 39.67 RCW;
>
> (4) A charge under RCW 36.89.080 through 36.89.100, for the furnishing of service to those who are receiving or will receive benefits from storm water control facilities of who are contributing to an increase in surface water runoff. Except as otherwise provided in RCW 90.03.525, any public entity and public property, including the state and state property, shall be liable for the charges to the same extent a private person and privately owned property is liable for the charges, and in setting these rates and charges, consideration may be made of in-kind services, such as stream improvements or donation of property;
>
> (5) The creation of local improvement districts and utility local improvement districts, the issuance of improvement district bonds and warrants, and the imposition, collection, and enforcement of special assessments on all property, including any state-owned or other publicly-owned property, specially benefited from improvements in the same manner as provided for counties by chapter 36.94 RCW.

Currently, the FCZD for the Skokomish Valley uses only the taxing option in (3), above, which is the $.50 per $1,000 of assessed valuation. While each of the above revenue options should be explored, (4) presents the most reasonable opportunity. Under (4), the FCZD may impose charges to those who contribute to an increase in surface water runoff. The link between increased flooding and upper watershed practices has been documented in this CFHMP, and it may be possible to assess charges to upper watershed contributors according to their contribution to increased flooding in the lower Valley. Since so much of the upper watershed is currently under a long-term commercial forest tax classification, which pays very little into the FCZD's levy fund owing to the low assessed value of such lands, a system of charges may be appropriate to compensate for the lack of flood control revenues coming from these lands.

Special Purpose Districts

There are several other special purpose districts with broader revenue generating authorities than the FCZD. These include Diking Districts (RCW 85.05), Drainage Districts (chapter 85.06 RCW), and Diking and Drainage Improvement Districts (RCW 85.08), all of which are municipal corporations that could replace the FCZD for the purposes of flood control, drainage improvement, and flood hazard mitigation.

Unlike the FCZD, these other districts are not subject to the $5.90 cap, and there is no limit on the levy rate per $1,000 of assessed value.

These special purpose districts have a level of independence not currently found in the FCZD, with their own elected commissioners rather than an advisory committee. Each of these special purpose districts must be formed according to the rules specified in RCW 85.38, Special District Creation and Operation. The process may be started either by a petition of at least 10 landowners within the proposed district or by resolution of the County legislative authority.

PROPERTY TAXES FROM THE CITY OF TACOMA

As part of an agreement between the City of Tacoma and Mason County, the City of Tacoma currently pays the County $100 thousand annually in lieu of property taxes for its Lake Cushman lands. The land around Lake Cushman has been developed into residential subdivisions that would normally pay property taxes to the County. The $100,000 goes into the County General Fund. More of this money could be earmarked for projects specifically within the Skokomish River watershed. In addition, it is recommended that the assessment currently paid by the City of Tacoma be re-evaluated to determine whether it is sufficient given the intensity of development of the Lake Cushman lands.

CHAPTER 8.
ENVIRONMENTAL IMPACT

Many of the projects and policies recommended in this CFHMP will cause unavoidable environmental impact. Each project will be required to undergo extensive environmental review during the permit process. During the permit process, the impact of a project on the area in which a project is proposed will be discussed, as will specific mitigation measures to address that impact.

The following is a summary of the kinds of impact commonly associated with projects recommended in this CFHMP. While many of the proposed projects may have an adverse impact on the environment, when designed and implemented properly many projects may also provide benefits both in flood hazard reduction and in environmental quality. For this reason, examples of benefits associated with each proposal are also provided.

DIKING

While no new dikes are currently recommended for the Skokomish Valley, a policy that includes construction standards for dikes was adopted by the CFHMP Planning Advisory Committee. The policy and the standards it promotes will affect the process by which dikes are permitted, constructed, and maintained.

Impact

Alteration of Flows

Dikes have the effect of modifying flood flows. Floodwaters that would otherwise inundate the area protected by a dike are diverted to other areas of the floodplain. This can have a negative impact on property both up- and downstream that otherwise would not have been flooded, or would have experienced less severe flooding.

Failure

Dike failure during severe flooding can result in even more severe flood damage in areas normally protected by the dike than would have been the case had the dike not existed at all. As the dike fails, accumulated floodwaters can create hazardous high-velocity flow paths.

Channel Scour

Dikes constructed close to the river channel can increase velocities within the channel as floodwaters rise, which can cause localized scour of river gravels. This scouring effect can adversely affect salmon spawning habitat.

Gravel Accumulation

While dikes can cause localized scour, their overall effect throughout the river channel can be an increase in riverbed aggradation. This is because dikes, especially those located close to the river channel, prevent floodwaters from dissipating throughout the floodplain. Rather than allowing flows to deposit their sediment loads throughout the floodplain, dikes channelize those flows, confining the sediment load to the channel.

Bank Erosion

Dikes constructed close to the river can increase channel velocities. The increased velocities can destabilize the riverbank both up- and downstream, resulting in bank erosion. Bank failures not only add sediment to the channel but can also jeopardize structures located along the river.

Removal of Side-Channel Habitat

Dikes are often constructed over river side-channels that offer excellent rearing and refuge habitat for juvenile salmon.

Water Quality

Dikes can have a short-term adverse impact on water quality during construction.

Wetlands

Wetlands are common throughout most floodplains, including the Skokomish River Valley. The construction of any dikes in the floodplain could result in filling wetlands or in altering wetlands hydrology.

False Sense of Security

Dike construction can foster a false sense of security it in many who consider residing in the floodplain. In many communities, the presence of dikes has encouraged development in areas that prove to be hazardous as dikes fail or as flooding patterns change.

Benefits

Properly constructed and maintained dikes can provide a level of flood protection benefits for structures and agricultural lands behind them.

BANK STABILIZATION

In several areas of the Valley, bank stabilization is seen as a viable strategy for reducing flood hazard to Valley residents. The area of the Skokomish Church and Five Mile Corner are two examples where structures are located close enough to the river bank to be endangered unless action is taken to either remove the structures or harden the bank.

Impact

Bank Hardening/Channelization

Whether the bank stabilization project uses "hard" methods such as riprap, or "softer" methods such as bioengineering, the purpose of the project is to harden, or stabilize the bank. Unintended consequences of the project can extend up- and downstream as the hydraulic forces that would normally be dissipated in the stabilized area are transferred to other areas along the river. By channelizing the river in one area, it is possible that other areas of the river will be made more susceptible to bank failure and erosion by these transferred hydraulic forces.

Water Quality

The construction phase of any bank stabilization project can produce a short-term adverse impact on water quality by disturbing soils and vegetation along the river bank.

Benefits

Reduction of Erosion

Erosion will be reduced on stabilized banks, thus reducing sediment inputs to the river channel. Structures threatened by eroding banks will be protected.

Restoration of Habitat

Banks stabilized with bioengineering will provide riparian vegetation.

GRAVEL REMOVAL

The aggradation of the Skokomish River channel is well documented. Gravel removal strategies for addressing this problem range from a comprehensive program to restore flows from the North Fork, combined with an extensive dredging operation, to small-scale gravel management projects that may be effective at reducing flood hazards in particular areas throughout the Valley.

Impact

Fisheries

Gravel removal projects can produce adverse environmental impact in a variety of ways, and much of the impact is directly on fish habitat. A thorough summary of fisheries concerns arising from gravel projects is presented in Chapter 6, Issue 1. Those concerns include the following:

- Adverse impact on spawning riffles due to changes in gradient, water velocity, and gravel composition
- Diminished gravel supplies for downstream spawning reaches
- Changes in pool and side-channel rearing habitats
- Stranding of fish in excavation pits left in gravel bars
- Loss from gravel bars of large woody debris that serves as habitat
- Adverse impact on water quality from disturbed sediments in the water column.

Noise

During the operation of the gravel project there will be noise associated with heavy equipment.

Construction of Access

Construction of access routes to the gravel operation could have an impact on wetlands in the floodplain. In addition, fill associated with the construction of access roads could create barriers to flood flows.

Riverbed Degradation

If gravel is overharvested in particular reaches, the result could be riverbed degradation. The potential impact of riverbed degradation includes the following:

- Bridge supports can be undermined
- Pipelines and other structures buried in the riverbed can be exposed
- The morphology of the channel can be changed, affecting aquatic habitat and salmon spawning sites
- Substrates underlying the river gravel can be exposed, affecting aquatic habitat
- Lateral bank erosion may be induced by increasing the height of river banks, which are then made more vulnerable to undercutting
- Removal of gravel bars may cause erosion of downstream bars
- Reduction in gravel supply can affect channel stability as gravel bars that are normally armored with gravel become destabilized
- As the riverbed is lowered, groundwater levels are lowered as well. This could cause a short-term reduction in riparian vegetation along the river bank.

Benefits

Reduction in Flooding

Flooding may be reduced as bed elevations decrease.

Reduction in Groundwater Levels

As the riverbed elevation is lowered, groundwater elevations will also lower. Residents in the Valley have observed rising groundwater levels over a number of years. A reduction in groundwater levels will restore to productive agricultural use lands that have become saturated or marshy.

Localized Flood Hazard Reduction

Small-scale gravel projects, such as gravel bar scalping, can reduce pressure on eroding banks where structures are threatened.

CHANNEL CLEARING/DEBRIS REMOVAL

Impact

Soil and Vegetation Disturbance

Heavy equipment used to remove debris could cause vegetation disturbance.

Wetland Disturbance

Debris removal in areas where there are wetlands could result in impact on wetlands from the operation of heavy equipment.

Noise

Noise disturbance to wildlife and adjacent land uses could result from the operation of heavy equipment.

Water Quality

Debris removal could cause a short-term adverse impact on water quality by disturbing sediments. Any operations near the river channel also risk the introduction of petroleum products from machinery, which would also adversely affect water quality.

Fish Habitat

Woody debris is an important habitat for fish. Excessive removal of debris could have an adversse impact on fish habitat. Any introduction of petroleum products from heavy machinery could also adversely affect fish and aquatic life.

Benefits

Removal of Flow Obstruction

By removing obstructions, flows that would otherwise spread over the floodplain will be more easily conveyed in the channel. Drainage following a flood will also be improved.

Reduction of Bank Instability

In some areas where debris has accumulated, the lateral diversion of flows can create instability of adjacent banks. Removal of debris can be expected to reduce hydraulic pressure on lateral banks in some cases.

REMOVAL OF OVERBANK VEGETATION

Impact

Loss of Vegetation

Loss of vegetation along the river bank means loss of riparian habitat. Loss of vegetation could also result in localized increases in water temperature, which could affect fish habitat.

Bank Erosion

Removal of vegetation could result in short-term stream bank erosion and increased sediment input to the river. Water quality would also be temporarily degraded.

Aesthetics

The removal of vegetation along the river, particularly trees, could have an adverse impact on the appearance of the river environment.

Benefits

Removal of vegetation in areas where the river channel is constricted could increase the overall channel capacity of the river in those areas.

WIDENING OF OPENINGS IN US 101 AND PURDY CREEK BRIDGES

The US 101 embankment runs perpendicular to the flow of the Skokomish River. When the river floods, the embankment pools floodwaters, increasing flood depths a quarter mile upstream by as much as 1.9 feet.

Impact

Downstream Impact

Increasing the conveyance capacity along the US 101 embankment, particularly at the Purdy Creek bridge, could increase the velocities and perhaps the depths of flood flows downstream of US 101. This could increase the flood hazard for residents in this area.

Water Quality

A short-term adverse impact on water quality can be expected from the replacement of bridge supports and from fill during the construction process. Petroleum products from heavy equipment could also enter the water.

Wetlands

Activities associated with construction, including the stockpiling of fill and the use of heavy machinery, could have an adverse impact on wetlands in the vicinity.

Channel Change

Increasing the conveyance capacity through the Purdy Creek bridge openings could facilitate a channel change as greater quantities and velocities of water are transported through this opening, which is at a lower elevation than the US 101 bridge.

Benefits

Widening the Purdy Creek bridge opening and raising the level of the bridge could provide approximately 0.5 feet of flood depth reduction for the area within 1,000 feet upstream of the bridge. Complete removal of the US 101 embankment could provide approximately 1.9 feet of flood depth reduction for the area within 1,000 feet upstream of the bridge.

DENSITY CRITERIA FLOODPLAIN REGULATION

Density criteria have been recommended to regulate floodplain development in the Skokomish Valley. Density criteria are an alternative to traditional floodplain regulations, which divide the floodplain into a developable flood fringe area and a nondevelopable floodway. Under density criteria, development is spread throughout the floodplain (with the exception of particularly hazardous areas where no new development would be allowed) at a density designed to raise base flood levels no more than a certain amount. For the Skokomish Valley, density criteria were established to allow no more than a 0.5-foot increase in flood levels if the entire Valley were developed to the allowable density.

Impact

Full development using density criteria will result in flood depths up to 0.5 feet greater than under existing conditions, resulting in increased flood damage.

Benefits

Development resulting in increased flood depths of greater than 0.5 feet would be prohibited, thus limiting flood damage.

FLOODPROOFING

Impact

The floodproofing of structures is expected to have little or no adverse impact on the environment.

Benefits

Structures that are properly floodproofed can be expected to withstand the effects of flooding with less damage.

EMERGENCY WARNING

Impact

Emergency warning systems, such as river gauges and emergency dialing systems, are expected to have little or no adverse impact on the environment.

Benefits

Improved emergency warning will reduce risk to persons living in the Valley as they will be better informed of impending floods and can evacuate when necessary.

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LIST OF ABBREVIATIONS

BPA—Bonneville Power Administration

CCC—Civilian Conservation Corps
CCWF—Centennial Clean Water Fund
CFHMP—Comprehensive Flood Hazard Management Plan
cfs—cubic feet per second
COE—United States Army Corps of Engineers
CFCMP—Comprehensive Flood Control Management Plan
CRS—Community Rating System
CTED—Washington State Department of Community, Trade, and Economic Development
CYSU—Cooperative Sustained Yield Unit

DEIS—Draft Environmental Impact Statement
DNR—Washington State Department of Natural Resources
DNS—Determination of Nonsignificance
DO—dissolved oxygen

Ecology—Washington State Department of Ecology
EIS—Environmental Impact Statement
EPA—United States Environmental Protection Agency
ESSB—Engrossed Substitute Senate Bill

FC—fecal coliform bacteria
FCAAP—Flood Control Assistance Account Program
FCZD—Flood Control Zone District
FCZDAC—Flood Control Zone District Advisory Committee
FEMA—Federal Emergency Management Agency
FERC—Federal Energy Regulatory Commission
FIRM—Flood Insurance Rate Map

GLO—Government Land Office
GMA—Growth Management Act
GPO—Government Printing Office

HPA—Hydraulic Project Approval

JRP—Joint Resource Parties

LID—Local Improvement District

mph—miles per hour

NFIP—National Flood Insurance Program
NPPC—Northwest Power Planning Council
NTU—nephelometric turbidity unit

OHWM—ordinary high water mark
ONP—Olympic National Park
ONF—Olympic National Forest

PAC—Planning Advisory Committee
PSAW—Puget Sound and Adjacent Waters (Study)
PUD—Planned Unit Development

RCW—Revised Code of Washington
RM—river mile
RV—recreational vehicle

SCS—United States Department of Agriculture Soil Conservation Service
SDP—Shoreline Development Permit
SEPA—State Environmental Protection Act
SMA—Shoreline Management Act
SMP—Shoreline Master Program
SR—State Route

TPU—Tacoma Public Utilities

US 101—United States Highway 101
USFS—United States Forest Service
USGS—United States Geological Survey

WAC—Washington Administrative Code
WSDOT—Washington State Department of Transportation
WDF—Washington State Department of Fisheries
WDFW—Washington State Department of Fish and Wildlife
WSE—water surface elevation