SKAGIT COUNTY COMPREHENSIVE FLOOD CONTROL MANAGEMENT PLAN

APRIL 1989

BC BROWN AND CALDWELL • CONSULTING ENGINEERS

SKAGIT COUNTY PUBLIC WORKS DEPARTMENT

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April 25, 1989

Mr. Don Nelson, Flood Control Engineer
Skagit County Public Works
County Administration Building, Room 203
Second and Kincaid Streets
Mount Vernon, Washington 98273

14-3234-01

Subject: Skagit County Comprehensive Flood Control Management Plan

Dear Mr. Nelson:

In accordance with our agreement for Engineering Services dated February 23, 1987, we are submitting the Comprehensive Flood Control Management Plan. In accordance with WAC 173-145-040, the document contains a determination of the need for flood control work, evaluation of impacts of the flood control alternatives, and a prioritized list of proposed solutions which are consistent with County goals and regulations.

For the convenience of those interested persons who wish to acquire a useable knowledge of the nature and scope of this study, we have included an Executive Summary in the report.

We have enjoyed working with you through the development of this plan. We would be pleased to be of further service to you and look forward to working with you again in the future.

Very truly yours,

BROWN AND CALDWELL

Phyllis A. Brunner
Project Manager

BROWN AND CALDWELL

Laura K. Belvin
Project Engineer

PAB:LKB:cp
Enclosure

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CFCMP	Comprehensive Flood Control Management Plan
FCAAP	Flood Control Assistance Account Program
FEMA	Federal Emergency Management Association
FIRM	Flood Insurance Rate Map
HPA	Hydraulic Project Approval
NFIP	National Flood Insurance Program

EXECUTIVE SUMMARY

A comprehensive flood control management plan is required by the State Participation in Flood Control Maintenance Act (RCW 86.26) for jurisdictions desiring State assistance for flood control management. The plan helps to protect and guide the use and allocation of state and local funds for flood protective works. The purpose of the plan is to establish the need for flood control work, define alternatives, and develop actions to solve flood control problems that are consistent with existing regulations and flood control goals.

Skagit County has faced flooding problems with the Skagit and Samish Rivers throughout its history. In order to control damage, over 80 miles of dikes and levees, drainage pumps, tide gates, holding ponds, and bank stabilization have been constructed and maintained by many diking and drainage districts. These facilities are subject to wear, however, and require continual maintenance. Several of these facilities are in need of major maintenance now. After a flood event, the relative severity of flood control maintenance problems change, and new problem areas occur. New problem areas can develop in response to changes in the river course or upper basin timber activities. Within this plan, 5 general areas in which related flooding problems occur have been identified, along with 14 specific problems within these areas. These areas are discussed in Chapter 2.

There are many structural and non-structural options to control flooding. Levees, coastal control, flood storage, channel maintenance or modification, and control of contributing areas are general structural options, and floodplain regulations, risk management, public education, and emergency response measures are some non-structural methods of controlling flood damage. These options are discussed in detail in Chapter 5. Each of the flood control options has its specific in-stream impacts and applicability to geographic areas and specific problems. The options used must also be consistent with existing regulations. Impacts of these flood control options are discussed in Chapter 6 and related regulations are covered in Chapter 4. The County has used most of these options throughout its history.

The development of flood control management actions must take into consideration the County flood control goals in alternative analysis and prioritization. These goals, discussed in Chapter 3, include reducing threat and damage, protection of economic base, provision of effective emergency response, maintain and improve existing facilities, maintain local control of flood control works, and provide Countywide protection.

A detailed analysis of each flood control alternative with respect to these goals is presented in Chapter 7. The resulting preferred alternatives for each geographic location are presented in Table ES-1.

Table ES-1. Preferred Flood Control Alternatives by Area

Area	Alternative				
	Maintain existing flood control works	Bank stabilization	Debris removal	Holding pond	Specific education
Leveed area	✓	✓			
Coastal	✓	✓			
Urban/rural	✓	✓			
Upper Skagit/ Samish Valleys	✓	✓	✓		✓
Feeder streams	✓	✓	✓	✓	

Due to the changing nature of flooding problems, a framework for prioritizing flood control work was developed in the management plan. Assessment of all flood control facilities and floodplain areas after a flood event is important to update the project list. After alternatives have been selected for the project areas, each is prioritized according to problem severity and ability to accomplish the County's flood control goals. Table ES-2 contains a general guideline of the priority of flood control projects Countywide. The actual prioritized list also reflects the severity of the problems. Table ES-3 lists prioritized projects for the 14 current problem areas. Their locations are shown on Figure 8-1 in the text. With approval of this plan, these projects will be planned in further detail, and will be submitted to the appropriate County and state agencies for funding and approval. Implementation of the projects is subject to local agency cooperation and coordination as Skagit County does not have full authority over all of the project areas.

This project prioritization list is for the current problem areas identified within the plan. The project and prioritization list will be updated upon assessment after a flood event. Unexpected emergency situations would be solved immediately, and are subject to a separate planning and funding process.

Table ES-2. Countywide Prioritization

Priority	Action
1	Maintain existing flood control works in leveed area.
2	Maintain existing flood control works in feeder stream area.
3	Enhance all existing flood control works County-wide.
4	Stabilize banks in Upper Skagit/Samish Valleys.
5	Remove point bar accumulations in Upper Skagit/Samish Valleys.
6	Maintain existing flood control works in urban/rural areas.
7	Improve drainageways in urban/rural areas.
8	Maintain existing flood control in Upper Skagit/Samish Valleys.
9	Stabilize banks along feeder streams.
10	Maintain existing flood control along the coast.
11	Remove debris from feeder streams.
12	Specific education programs County-wide.
13	Install holding ponds along feeder streams.
14	Form additional districts where necessary.

Table ES-3. Current Prioritized Project List

Priority	Project	Area
1	No. 7--North Fork sloughed levee	Leveed area
2	No. 8--Padilla Dike piling	Coastal area
3	No. 12--Gages Slough drainageway	Urban/rural area
4	No. 5--Cape Horn road bank stabilization	Upper Skagit Valley
5	No. 6--Big Ditch underpass repair	Leveed area
6	No. 10--Highway 9 bridge bank stabilization	Upper Skagit Valley
7	No. 9--Hansen Creek holding pond	Feeder streams
8	No. 1--Friday Creek bank stabilization	Feeder streams
9	No. 15--Grady Creek debris removal	Feeder streams
10	No. 14--Specific education program for Hamilton	Upper Skagit Valley
11	No. 11--Burlington point bar accumulation removal	Upper Skagit Valley
12	No. 3--Remove point bar accumulations near Lyman	Upper Skagit Valley
13	No. 13--Specific education program for Cockreham Island	Upper Skagit Valley
14	No. 4--Remove point bar accumulation near Van Horn	Upper Skagit Valley
15	No. 2--Remove point bar accumulation near Gilligans Creek	Upper Skagit Valley

CHAPTER 1

INTRODUCTION

Flood protection and drainage of excess water have been concerns of the people of Skagit County since the earliest agricultural settlements were established. The County has a long history of flooding problems which have cost the County residents and businesses millions in damages. Substantial flood protection work and drainage facilities have been constructed and operated by local interests, both public and private, to help alleviate the problems.

Funding for many of the flood control projects was made available through the State Participation in Flood Control Maintenance Act (Chapter 86.26 Revised Code of Washington [RCW]) originally enacted in 1951. The Act had provided a funding mechanism to cost share with local jurisdictions in the construction of facilities for flood control maintenance. Typical projects included the installation of rock riprap on eroding streambanks or on failing existing riprap or levees. Funding was based on a legislative appropriation each biennium with the amount varying from a maximum of two million dollars per biennium, to no funding for approximately the last 10 years.

Significant modifications were made to the Act in 1984. The purpose of the amendments to the Flood Control Assistance Account Program (FCAAP; RCW 86.26.007) is to protect and guide the wise allocation of State and local funds for flood protective works. A new requirement of the Act is that each jurisdiction desiring State assistance for flood control maintenance must prepare a Comprehensive Flood Control Management Plan (CFCMP).

PROBLEM STATEMENT

The purpose of comprehensive flood control management planning is to establish the need for flood control maintenance work, define structural alternatives, identify and consider potential impacts of in-stream flood control work on in-stream resources, and identify the river's floodway.

In order to continue to be eligible to receive funds from the Flood Control Assistance Account Program, Skagit County must develop and adopt a CFCMP as specified in Washington Administrative Code (WAC) 173-145. The County retained Brown and

Caldwell to provide necessary engineering services in connection with the State requirements.

SCOPE OF WORK

Skagit County engaged the services of Brown and Caldwell to conduct the Comprehensive Flood Control Management Plan under an Agreement for Engineering Services dated February 23, 1987.

In compliance with WAC 173-145-040, the following tasks and subtasks will be performed in the development of the plan:

- Determination of the need for flood control work through a description of the watershed, identifying types of flood problems and potential damages, locating specific problem areas, determining goals and objectives for the planning area, and addressing the applicable regulations.
- Identify the areas that are subject to flooding.
- Examine flood control alternatives including structural and alternative in-stream flood control work.
- Identify potential impacts on in-stream uses and resources.
- Evaluate and prioritize the proposed flood control actions.
- Summarize proposed solutions.
- Provide a document ready for review and adoption.

BACKGROUND MATERIALS

The information for this plan has been condensed from several studies on the Skagit and Samish River systems. The studies cited are listed in the bibliography in Appendix A, and include those prepared by the Corps of Engineers, the Federal Emergency Management Agency (FEMA), Skagit County, and the Soil Conservation Service. Information was also obtained from County records and legislation, as well as interviews with staff engineers and planners.

CHAPTER 2

WATERSHED DESCRIPTION AND FLOODING PROBLEMS

Skagit County has abundant resources of water, with the Samish and Skagit Rivers within its borders. These rivers have a history of flooding, however, and have caused extensive damage to major sections of the county, affecting the county's economy, resources, and way of living. This chapter describes the watershed area of the two rivers, the flood history, the typical flooding problems experienced, and the potential damage flooding causes. The areas which have had specific flooding problems are also discussed.

DESCRIPTION OF WATERSHED

Skagit County has within its boundary four major watersheds: Skagit, Samish, Nooksack, and Stillaguamish, as presented in Figure 2-1. The flood plains of the two latter watersheds are located outside the County's boundary and will not be included in this plan. The Skagit and Samish basins comprise an area of 3,277 square miles between the crest of the Cascade Mountains and Puget Sound.

Elevations within the Skagit and Samish drainage basins range from sea level at LaConner to 10,778 feet at the summit of Mount Baker. The northern end of the Skagit Basin extends 28 miles into British Columbia, where it borders the Frazer River Basin. The extremely rugged topography in the vicinity of Mount Baker gives way in the western part of the Skagit Basin to rolling country with a wide flat valley. Exclusive of the small area in Canada, the Skagit Basin has an area of 2,750 square miles. During major floods the Skagit River overflows a low divide between the Skagit and Samish River flood plains and the floodwaters from both streams intermingle on the Samish River flood plain. Flood problems of the two streams are, therefore, related, and both basins are generally treated as one large flood plain.

Skagit River

The Skagit, third largest river in the western portion of the United States, flows southwesterly from its source high in the Cascade Mountains in Canada for 163 miles to tidewater in Skagit Bay, an arm of Puget Sound. It falls 1,600 feet in this distance, 1,300 feet from its source to Marblemount. The remaining 300 feet of fall are distributed over 92 miles in the lower basin. The river flows through a delta in two main channels, the North Fork

and the South Fork, about 10 miles above the mouth, below Mount Vernon. These forks are nearly equal in length and during the usual range of river discharge the flow is so divided that about 60 percent is carried by the North Fork and 40 percent by the South Fork. The river is tidal to the Great Northern Railway bridge 15.4 miles above the mouth. The mean diurnal range of tide at the mouth is 11.1 feet and the extreme range is 19 feet.

Three major tributaries augment the Skagit's flow; the Cascade, which joins it near Marblemount; the Sauk near Rockport; and the Baker at Concrete. Several small watersheds are also tributary to the Skagit. These include the Illibot Creek, Finney Creek, Day Creek, and Nookachamps Creek watersheds. Many additional feeder streams also discharge directly into the Skagit River.

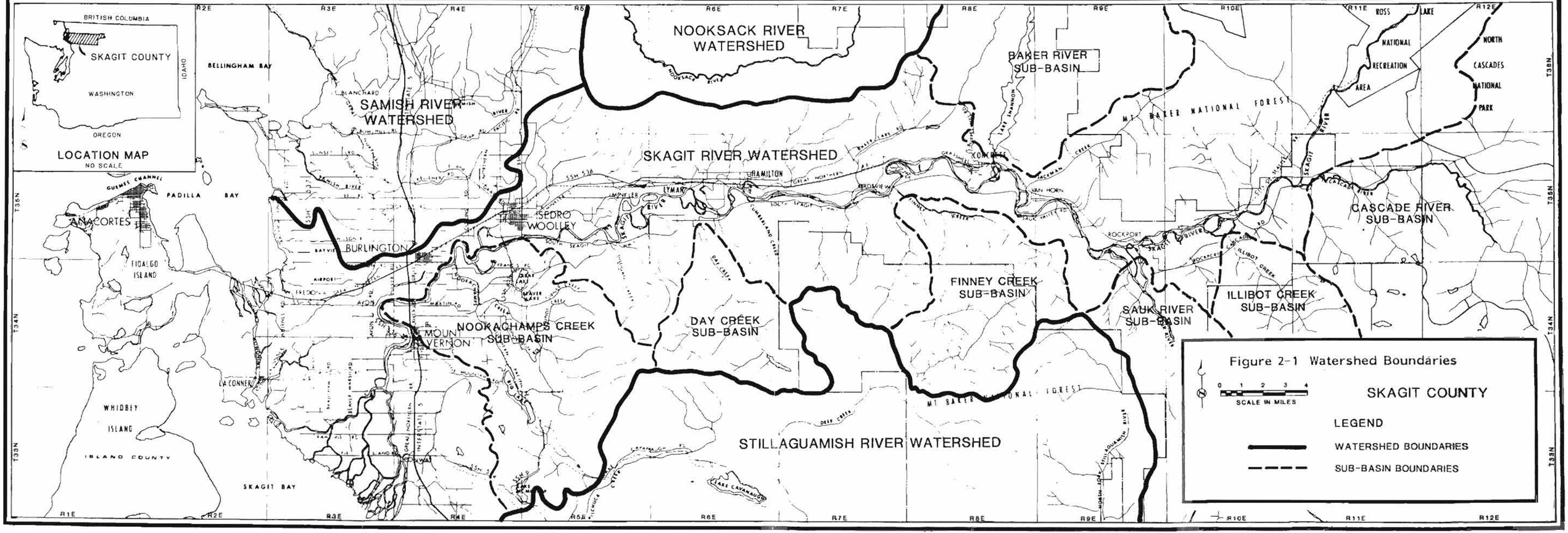
Ross Dam Reservoir on the Skagit River controls the drainage from 978 square miles of watershed. It provides storage and head for a hydroelectric plant at the dam and supplements low flows for run-of-the-river hydroelectric plants at Diablo and Gorge Dams. Hydroelectric developments on the Baker River, a tributary to the lower Skagit River, include Lake Shannon controlling 270 square miles of watershed and Baker Lake, controlling an additional 215 square miles of watershed. A diversion system for supplying water to the city of Anacortes is located at Avon near Mount Vernon.

The Samish River

The Samish River drains about 139 square miles between the Skagit River Basin on the south and the Nooksack on the north. The Samish River originates on a low divide south of Acme in Whatcom County, and its tributary, Friday Creek, originates in the hills south of Bellingham. The river has a very narrow flood plain and flows much of its 20-mile length in a southwesterly direction between steep and rugged mountains. It outlets into Samish Bay, near Edison.

The Flood Plain

The entire floor of the Skagit River Valley, the deltas of the Samish and Skagit Rivers, and reclaimed tidelands adjoining the Skagit, Samish, and Stillaguamish River Basins comprise the flood plain. The flood plain covers 90,000 acres, including 68,000 acres of fertile land downstream and west of the city of Sedro Woolley, and 22,000 acres of river bottom land east and upstream of this city. The valley upstream from Sedro Woolley is narrow and relatively undeveloped, the agricultural area extending in general only to Concrete. Even in the reach from Sedro Woolley to Concrete, about two-thirds of the bottom land is uncleared or is occupied by river channels and sloughs. The width of the flood plain varies from less than one mile along the tributaries and


BRITISH COLUMBIA
SKAGIT COUNTY
WASHINGTON
OREGON
IDAHO
LOCATION MAP
NO SCALE
NOOKSACK RIVER WATERSHED
SAMISH RIVER WATERSHED
SKAGIT RIVER WATERSHED
BAKER RIVER SUB-BASIN
NOOKACHAMPS CREEK SUB-BASIN
DAY CREEK SUB-BASIN
FINNEY CREEK SUB-BASIN
SAUK RIVER SUB-BASIN
ILLIBOT CREEK SUB-BASIN
CASCADE RIVER SUB-BASIN
STILLAGUAMISH RIVER WATERSHED
BELLINGHAM BAY
PADILLA BAY
GUEMES CHANNEL
ANACORTES
FIDALGO ISLAND
BURLINGTON
SEDRO WOOLLEY
MOUNT VERNON
CONWAY
WHIDBEY ISLAND
ISLAND COUNTY
SKAGIT BAY
HAMILTON
LYMAN
ROCKPORT
MT BAKER NATIONAL FOREST
ROSS LAKE NATIONAL RECREATION AREA
NORTH CASCADES NATIONAL PARK
LAKE CAVANAUGH
Figure 2-1 Watershed Boundaries
SKAGIT COUNTY
SCALE IN MILES
0 1 2 3 4
LEGEND
WATERSHED BOUNDARIES
SUB-BASIN BOUNDARIES

upper reaches of the main stem to over 20 miles in the lower reaches. The upper flood plain is characterized by flat benches along the river which are heavily covered with vegetation and sharply defined by steep canyon walls. Much of this area is unsuitable for farming because of the sandy, rocky soil and the changeable nature of the river channel in the steeper sections. Below Sedro Woolley the valley drops almost to sea level and widens to a flat, fertile outwash plain adjoining the Samish Valley to the north. These fertile lands are ideal for farming. The outwash plain extends west through Mount Vernon to LaConner and south to the flood plain of the Stillaguamish River.

Potential flood damage in the Skagit River Basin is greatest in the flood plain. The flood plain is primarily agricultural, but includes a large proportion of the county's urban and rural population, many manufacturing plants, and major transportation routes.

Climate and Hydrology

Runoff from the Skagit River basin depends on rainfall and snowmelt as provided by climatic conditions. Due to the proximity of the Pacific Ocean to the Skagit Basin, the influence of maritime air masses is pronounced in both the temperature and precipitation regimes, producing a mild but wet climate. During the winter, the Skagit Basin, lying directly in the storm path of cyclonic disturbances from the Pacific Ocean, is subject to numerous storms, which are frequently quite severe and may follow one another in quick succession. On the mountain slopes, storm precipitation is heavy and almost continuous as a result of combined frontal and orographic effects. During summer months, the weather is warm and relatively dry as the Alleutian low pressure system is displaced by a semi-permanent high pressure system. The Skagit River Basin is subject to winter rain floods and annual high water due to snowmelt runoff. Low flows occur during August and September after the snowpack has melted and the ground water flow has been partially depleted. A summary of streamflow data for the key stream gages is shown in Table 2-1.

Table 2-1. Streamflow Data--Skagit River Basin[a]

Stream gage location	Drainage area, square miles	Number of years of record	Discharge, cfs		
			Average	Maximum	Minimum
Skagit River					
At Newhalem	1,175	70	4,484	63,500	136
Near Concrete	2,737	54	15,190	154,000	2,610
Near Sedro Woolley	3,015	19	16,230	220,000	2,830
Near Mount Vernon	3,093	38	16,810	144,000	2,740
Sauk River					
Near Sauk	714	52	4,402	82,400	572
Baker River					
At Concrete	297	39	2,677	36,600	30

[a]Based on records of the U.S. Geological Survey through September 1978.

HISTORY OF FLOODING

Throughout the years, major flooding has occurred in the Skagit River Basin. Because of its geographic location, the Skagit River Basin is subject to winter rain floods and an increase in discharge during spring due to snowmelt runoff. Rain-type floods occur usually in November or December, but may occur as early as October or as late as February. Antecedent precipitation serves to build up ground water reserves. Frequently, a light snow pack is then formed over most of the entire basin. A heavy rainfall accompanied by warm winds completes the sequence which produces major floods. The heavy rainfall and accompanying snowmelt result in a high rate of runoff, as the ground is already nearly saturated from earlier precipitation. Two or more crests may be experienced within a period of a week or two as a series of storms move across the basin from the west. The winter floods have a considerably higher magnitude than the average annual spring high water.

The snowmelt peak is expected during the spring or early summer, caused by the seasonal rise in temperatures with resultant melting of the accumulated snowpack. These high discharges may have a minor contribution from warm rains, but are caused predominantly by snowmelt. The spring snowmelt is characterized by relatively slow rise and long duration. While this high water occurs annually, it seldom reaches a damaging stage. During the annual spring or early summer high water, power reservoirs are filling, and as a result, the spring peak discharges are frequently reduced.

The magnitude and intensity of a storm cannot always be used as an index of the resultant river discharge. Other factors, such as temperature sequence, degree of soil saturation, and moisture content of the snowpack largely influence the rate of and total runoff produced by a particular storm. Conditions preceding a storm may be such that even a moderate storm could set in motion the related factors that, collectively, result in a flood. Conversely, conditions in the drainage basin may be such that a severe storm results in only minor high water.

Historical floods experienced in the Skagit River basin through 1975 have been described by USGS Water Supply Paper 1527. A brief description of these is as follows.

About 1815: Highest flood; gauge height of 20 feet at Diablo Dam; at Rockport the river was at least 15 feet above the flood mark of the 1917 flood; at Concrete a gauge height of 69.3 feet; at Sedro Woolley the flood exceeded the 1909 flood by 7 feet, covered the highest ground in the town with 1.5 feet of water, about 10 feet of water in present business district, and a gauge height of 63.5 feet.

1856: Second highest flood; Reflector Bar (Diablo Dam) gauge height of 18.5 feet; Concrete gauge height of 57.3 feet; Sedro Woolley gauge height about 60 feet.

November 19, 1897: From Birdsview east, the highest the river has ever been due to a warm chinook wind and heavy rain, the river rose suddenly and after 36 hours the rain subsided suddenly. Cascade, Sauk, and Baker Rivers were high and caused a peak on the Skagit at the mouths of each stream. Because of the sudden stopping of the rain, channel storage greatly reduced the crest as it was moving downstream. At Marblemount and Concrete the flood was 1.3 feet and 3.6 feet higher, respectively, than the 1909 flood.

November 30, 1909: A series of low pressure storms moved through the area, with the last storm moving in on November 26 and lasted through November 29th, dumping 8.3 inches of precipitation at Sedro Woolley. On the 26th and 27th the precipitation was in the form of snow above 2,500 feet. But on the 28th and 29th a warm rain melted snow up to 4,000 feet elevation. The result was the largest flood since the initiation of flood records. At the Reflector Bar (Diablo Dam), the crest was 2.4 higher than the 1897 flood. At Newhalem the gauge was 22.0 feet above the datum gauge. At Concrete, the gauge was 36.4 feet with water reaching the footing of a hotel near the cement plant. Down river the flood breached a dike near Burlington, pushing water over most of the land between Burlington and the Swinomish Channel. The gauge height at Sedro Woolley was 56.5 feet.

December 30, 1917: This flood was remarkable for the length of time it remained high, rather than the crest, which was comparable to the 1896 flood and was 2.5 feet below the 1909 flood crest. At Sedro Woolley, the gauge was 54.1 feet.

December 12 - 13, 1921: The weather in November of 1921 was below average temperatures and excessive precipitation. December was cold, but snowfall was less than average, much of which was melted off by excessive rain on the 10th and 12th. Between 6:00 p.m. of the 9th and midnight on the 12th Silverton (in Snohomish County, east of Everett) received 14.2 inches of precipitation, David Ranch near Ross Dam received 10.2 inches and 3.4 inches fell at Sedro Woolley. Twenty-four hour maximum rainfall records at these stations were 5.9, 5.0, and 2.0 inches, respectively. These conditions created the second largest flood on record and caused a dike break just above the Great Northern Railway bridge between Mount Vernon and Burlington, dumping 60,000 cubic feet per second (cfs) of water into the Samish River Delta area.

November 1949: The flood of November 1949 is a good example of the flattening of a flood crest as it moves downstream. Channel storage had a marked effect on the sharpness of the peak between Concrete and Mount Vernon. The peak discharge of 154,000 cfs near Concrete was reduced to 114,000 cfs near Mount Vernon. Precipitation records in the basin at the time of this flood partly explain the reduction in crest in the lower reaches of the channel. The Sedro Woolley gage indicates that very little rain fell in the lower part of the basin.

February 10 - 11, 1951: The 1951 flood was an example of a long duration flood. Although the peak discharge was smaller, the duration of high water was considerably longer than the 1949 flood. At Concrete, the crest reached a discharge of 129,000 cfs (10-year flood frequency) compared with 153,000 cfs (14-year flood frequency) in the 1949 flood. The difference though, can be seen when comparing the Mount Vernon discharge. For 1951, the crest reached 144,000 cfs (15-year flood frequency) compared with 114,000 cfs (5-year frequency) in 1949. This flood caused a major levy break near Conway.

December 1975: On November 30th, a cold front moved into the Skagit area covering the area between Burlington and the Cascades with a moderate amount of snow. On December 1st a new front moved into the area raising the freezing level higher up in the mountains and dumping rain on the valley as the temperature continued to raise. Melting snow and rain water began swelling ditches, streams, and the Skagit River, which began flooding some time Tuesday night. The weather continued to stay warm and rainy through Wednesday with wind coming up in the afternoon causing wave action which

threatened dikes and other structures along the river. Several critical periods were met during the flood when tides were high and winds strong. Peak high water level was reached Thursday night when the river crested at 35.6 feet at the Riverside Bridge in Mount Vernon. Twenty-six feet of water in the river at this point is considered flood stage by the Skagit County Engineers. Clear weather and cooler temperatures beginning Thursday affected immediate receding along the river as soon as the crest passed. By Friday, December 5th, the water level was dropping and water receded at a remarkably rapid rate. The river lacked only 2,000 cfs of becoming a flood of the same magnitude as the 1951 flood which caused a major levee break near Conway. At the time of the flood crest at Concrete (which amounted to a measured value of 122,000 cfs) the inflow into Ross Reservoir was approximately 24,000 cfs, therefore, the added inflow into Ross Reservoir that was not released, namely, 19,000 cfs would have added substantially to the Concrete crest, thereby creating a peak flow of approximately 141,000 cfs. Ross Dam had control over approximately 17 percent of the river flow at that time. It has been calculated that the control they had enabled them to reduce the flood level at Concrete by approximately 2.5 feet.

Flooding since 1975: Three major flood flows have occurred since the USGS Water Supply paper was written. Floods with magnitudes of 135,800, 148,700, and 100,000 cfs occurred in Concrete on December 18, 1979, December 26, 1980, and December 4, 1982, respectively. The Town of Hamilton was completely inundated each time. Cockreham Island levees overtopped and failed in 1979 and 1980. The levee system protected the Lower Skagit Valley and most of the damage occurred upstream of Sedro Woolley. Each of these floods was incurred by heavy, warm rains accompanied by a melting of the snow accumulation in the lower elevations.

Major damage-causing floods can be expected to continue to occur at rare intervals. If all the flood-producing conditions should take place at the same time, the unlikely would become the possible. For example, if the river should be running high, with soil saturated and a deep, wet snowpack over the basin, and if a series of storms should follow each other in from the Pacific Ocean, precipitation and snowmelt could cause a flood much larger than the 1909 flood.

TYPES OF WATERSHED FLOODING PROBLEMS

Skagit County has faced flooding problems in its watersheds throughout its history. In general, inundation and standing water that causes property damage are the typical problems during high stream flow periods. The types of problems can be categorized by watershed area.

Leveed Area

When the Skagit River reaches flood stage in the flood plain several types of problems can occur. The rapid flows tend to erode the stream bank as the river attempts to rechannel itself. The existing levy that hold the river in place suffer from erosion and deterioration also. The levees have failed in the past, causing extensive damage to agricultural land and private and public property. Heavy rains that fall on the flood plain travel toward the river but are unable to cross the levees. This water ponds up at the pumping facilities. Extensive water overburdens the stations, putting them at a risk of failure. The elevated height of the river causes high water table levels, which can result in sand boiling near the toe of the levees. Extended periods of high water cause productivity losses in the agricultural lands. Heavy stream flows carry large amounts of sediment, which deposit on surrounding property if the levees fail or overtop. Levees are at risk of overtopping and emergency vehicles are unable to access the inundated areas, and are unable to administer needed emergency service.

Coastal Areas

Almost all of the westerly boundary of the County has been saltwater-diked. High winds and high tides cause deterioration to the dikes and breakwaters, requiring repair. Dikes are at risk of overtopping and failure when high tides are accompanied by high winds and low barometric pressure. The land becomes affected by the added salinity, reducing agricultural productivity.

Upper Skagit/Samish Valleys and Feeder Streams

The areas upstream of Sedro Woolley are generally unprotected from flooding; the levee system generally extends only to the Burlington area. Extensive areas near Nookachamps Creek and along the upper valley flood plain are inundated for extended periods of time during high water periods.

Feeder streams, although having high gradients and no real flood plain of their own, cause flooding problems as they approach the Skagit and Samish Rivers. The high-energy flows have a tendency to leave their stream channels, and flow over nearby fields, depositing sediment and debris in the pathway.

Undersized, broken, and misaligned culverts do not allow the flows to pass, causing extensive ponding behind them. The rising water can spill over road or railway fills, creating a falls which may completely wash out the fill.

As timber is removed from the forested areas, an increase in runoff occurs. The excessive amounts of water come down the hillside, causing erosion and picking up debris and sediment that are deposited at lower stream gradients. The high flows carry logs, brush, and small structures, which tend to jam around bends or constrictions, causing a backwater behind the jam. Bridges crossing these streams are at risk of damage from the debris and from undermining of bridge foundations.

Urban and Rural Areas Away from the River

Development has encroached on the flood plain areas and has brought with it an increase in paved, impervious surfaces. This has caused increased peak flows and volumes which can overwhelm the existing storm sewers and cause local flooding problems. Agricultural areas downhill of the developed areas experience difficulty in handling the increased runoff. Poorly-maintained ditches do not carry the water off rural sites quickly, causing standing water and ponding in these areas.

POTENTIAL FLOOD DAMAGE

The potential for loss of life and monetary damage from a flood is great. Existing flood control measures mitigate potential flood damage somewhat, but the protection level differs throughout the County. The maximum protection achieved is for floods occurring at a frequency of once every 25 years, while other areas have little or no protection. Continuing residential and commercial development in the flood plain will increase the potential for damage.

The flooding problems discussed for each of the five different geographic areas cause considerable damage. The damage done by floods can be separated into three different categories. Physical damage is caused to structures, public and private, with losses in equipment, material, and furnishings. Financial loss results from decreased production, and the situation increases living expenses and operation cost. Cleanup, emergency, and relief activities require an enormous effort and expense. Each of these types of damage apply to the businesses, residences, and public utilities in the floodplain area.

Residential

Homes in the floodplain may be inundated, furniture waterlogged, basements filled with sediment and debris, heating facilities ruined. Yards, sidewalks, fences, and septic tanks are damaged. With greater depth and the force of flowing water, buildings may be moved off their foundations or undermined.

Commercial

Properties used in commerce, business, trade, services, and entertainment are affected. Land, buildings, equipment, supplies, merchandise, and raw material all can suffer loss or damage. Overhead expenses are increased for cleanup and inventorying. Normal operations costs increase and net profit is substantially reduced for the period.

Agriculture

Loss and destruction occurs to growing crops, land, barns, equipment, feed, livestock, and fences. The removal of debris, weed, and seed from affected land is time-consuming and costly. Siltation and saltwater can cause the soil to be less productive and fertile. Specialty horticulture such as bulbs and berries can be substantially damaged. Prolonged periods of high water are especially damaging. As agriculture is the major economic entity, extensive flood damage causes economic hardship to the entire county.

Public

Schools and roads are damaged and become unfit for use. Electric, water, telephone, and sewer utilities services can be interrupted, with additional problems if these services are needed for emergency purposes. Water rushing over roadways can potentially wash them out. Bridge foundations can be undermined when debris is trapped on piles and girders, causing an additional rise in the water surface.

Emergency Aid

The preservation of life and property are priority concerns during a pending flood. Flood emergency preparations are made. Evacuations are assisted. Additional police protection is needed. Rescue operations are performed. Mobilization of sandbagging teams of residents and military is needed. After the flood has passed, debris and wreckage is removed, and channels cleared. Private and public facilities are repaired or replaced. Damaged flood control works need restoration or repair.

Costs

The costs associated with the potential damages are difficult to determine. Historic estimated costs do not have a similar basis of comparison, nor have they taken into account all of the factors that have been damaged. In general, damages increase exponentially with respect to the size and duration of the flood. Table 2-1 contains available flood damage estimates of some of the major flood events. Flood damage has been reduced in recent years with the storage of water behind Ross and Upper Baker dams, and with an extensive, well-maintained levee and dike system on the Lower Skagit River, and a well organized and effective flood fighting effort.

Table 2-2. Summary of Discharge Data and Flood Damage Estimates[a]

Date	Station					Damages in flood plain west of Sedro-Woolley (million dollars)[f]
	Skagit River near Concrete (2,737 sq mi)		Skagit River near Sedro-Woolley (3,015 sq mi)	Skagit River near Mount Vernon (3,093 sq mi)		
	Peak discharge, cfs	Recurrence interval, years[b]	Peak discharge, cfs	Peak discharge, cfs	Recurrence interval, years[b]	
1815	500,000		400,000	--		--
1856	350,000		300,000	--		--
November 16, 1896	--		185,000	--		71.4
November 18-19, 1897	275,000		190,000	--		71.9
November 16, 1906	--		180,000	180,000		70.9
November 18, 1908	--		97,000	--		--
November 29-30, 1909[g]	260,000	70	220,000	--		84.4
November 21, 1910	--		114,000	--		--
December 29-30, 1917	220,000	33	195,000	--		72.4
December 12-13, 1921	240,000	50	210,000	--		79.6
February 27, 1932	147,000	8	--	--		63.7
November 13, 1932	116,000	5	--	--		39.6
December 22, 1933	101,000	3	--	--		14.1
January 25, 1935	131,000	7	--	--		54.3
November 27, 1949[c]	154,000	14	149,000[b]	114,000	8	41.2
February 10, 1951[c]	139,000	10	150,000[b]	144,000	18	68.2
November 3, 1955[d]	106,000	6	113,000[b]	107,000	6	NA
November 23, 1959[e]	89,300	4	--	91,600	4	2.3
November 20, 1962	114,000	7	--	83,200	3	NA
July 13, 1972	91,900	4	--	80,600	3	NA
December 4, 1975	122,000	10	121,000	130,000	12	7.3
December 18, 1979	135,800	14	--	111,900	10	NA
December 26, 1980	148,700	17	--	113,900	10	NA
December 4, 1982	100,000	5	--	71,370	2	NA

[a] Flows from USGS records except as noted.
[b] Estimated by Corps of Engineers.
[c] Ross Dam began storing water in March 1940, and affects downstream flow and flood recurrence intervals.
[d] Includes effect of 120,000 acre-feet of flood storage established at Ross Dam in 1953.
[e] Upper Baker Dam began storing water in July 1959.
[f] ENR = 4800, equivalent to mid-1987 costs.
[g] First official recorded flood.
NA = Data not available.

LOCATION AND IDENTIFICATION OF PROBLEM AREAS

Specific problem areas can be identified for each of the typical watershed flooding problems listed previously. Some of the problems are too widespread or have frequent changes in location and cannot be pinpointed specifically. These areas need to be addressed when it is apparent that a problem is developing. Existing flood control works which are in the main watercourse of the river are subject to constant abuse, and must be maintained continually.

Specific Problem Areas

Several areas have or are developing problems that need additional attention. These areas are numbered in Figure 2-2. This list is not self inclusive, as problem areas frequently develop unexpectedly.

Area No. 1: Friday Creek bank erosion, Section 32, Township 36 North, Range 4 East--At this location, Friday Creek makes a 90-degree turn. The stream force is directed into a high, unstable bank and considerable erosion has occurred. The possibility of a major landslide exists. This could cause a temporary dam on Friday Creek that could overtop, causing a surge of water and debris downstream.

Area No. 2: Gilligan's Creek bar accumulation, Section 24, Township 35 North, Range 5 East--A large amount of erosion has occurred to the right bank of the Skagit River near the entrance of Gilligan's Creek. A large sand bar is building along the left bank. The velocity is quite high and it is likely that a channel change could occur at this location.

Area No. 3: Lyman point bar accumulation, Section 18, Township 35 North, Range 6 East--About 600 feet of the right bank of the Skagit River has eroded. A large sand bar is building on the left bank, and a channel change could occur at this location.

Area No. 4: Van Horn channel change, Section 24, Township 35 North, Range 8 East--Much of an old log jam has been washed away from the mouth of an old slough along the left bank of the Skagit River. The river could re-enter the slough, causing a channel change.

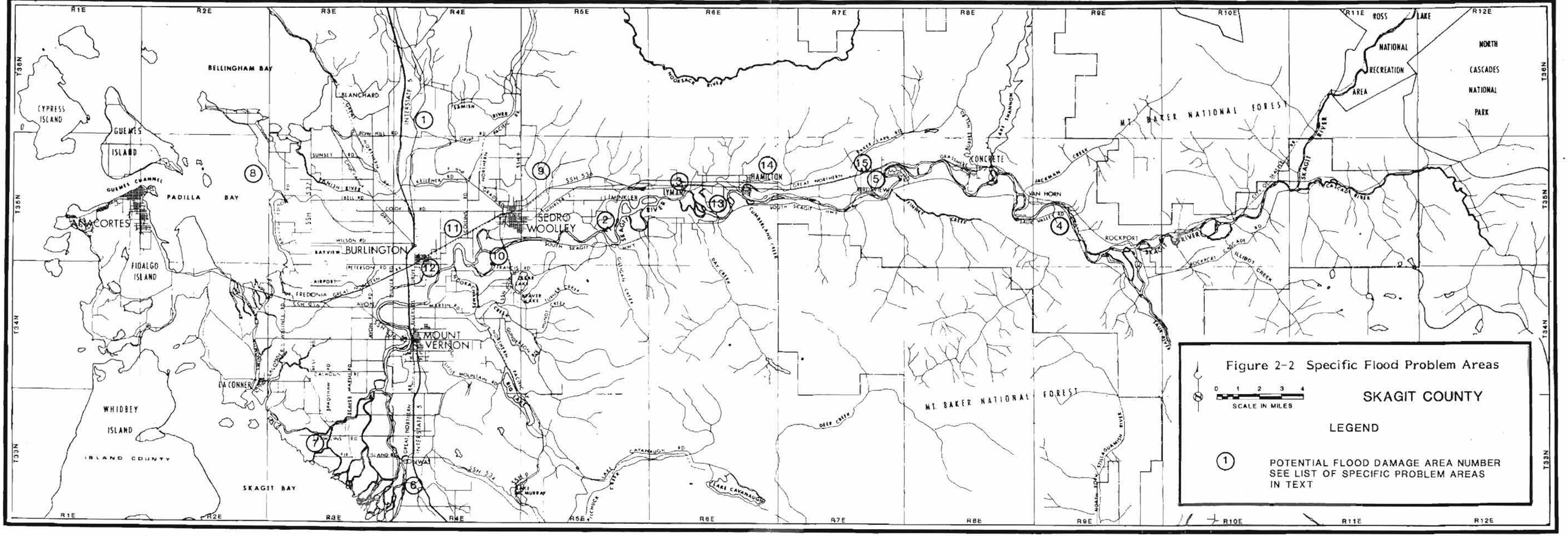


Figure 2-2 Specific Flood Problem Areas
SKAGIT COUNTY
SCALE IN MILES
0 1 2 3 4
LEGEND
1 POTENTIAL FLOOD DAMAGE AREA NUMBER SEE LIST OF SPECIFIC PROBLEM AREAS IN TEXT
BELLINGHAM BAY
CYPRESS ISLAND
GUEMES ISLAND
GUEMES CHANNEL
PADILLA BAY
ANACORTES
FIDALGO ISLAND
BLANCHARD
BURLINGTON
SEDRO WOOLLEY
LYMAN
HAMILTON
CONCRETE
MOUNT VERNON
LA CONNER
WHIDBEY ISLAND
ISLAND COUNTY
SKAGIT BAY
MT. BAKER NATIONAL FOREST
ROSS LAKE NATIONAL RECREATION AREA
NORTH CASCADES NATIONAL PARK
ROCKPORT
VAN HORN
JACKMAN CREEK
SKAGIT RIVER
CASCADE RIVER
SAUK RIVER
SUIATTLE RIVER
NOOKSACK RIVER
SAMISH RIVER
PILCHUCK CREEK
LAKE CAVANAUGH
LAKE MURRAY
INTERSTATE 5
SSH 538
SSH 536
SSH 530
SSH 20
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
R9E
R10E
R11E
R12E
T36N
T35N
T34N
T33N

Area No. 5: Cape Horn road bank erosion, Section 12, Township 35 North, Range 7 East--The Skagit River makes a long curve along a high gravel bank about 60 feet high. The right bank of the river has eroded to within about 30 feet of the Cape Horn Road.

Area No. 6: Big Ditch pass deterioration, Section 30, Township 33 North, Range 3 East--At this location, the Big Ditch pass is under Fisher Creek in a large concrete box culvert. Fisher Creek is diked along both sides. This underpass was constructed in approximately 1936. It appears that the forms were never stripped from the structure and are now rotting away. Some problems have been experienced with water flowing under the structure and through the dike. It may be that some major repair will be needed should this problem continue.

Area No. 7: North Fork sloughed levee, Section 9, Township 33 North, Range 3 East--The levee along the left bank of the North Fork of the Skagit River has sloughed badly. The levee is quite narrow at this point with very steep slopes, less than 1:1. Also, the levee is very close to the river channel. About a 1,000-foot section of this levee is in need of major repair.

Area No. 8: Padilla Dike deterioration, Section 1 and 12, Township 35 North, Range 2 East and Section 18, Township 35 North, Range 3 East--The Padilla Dike along this area is protected from a strong wave action by a long row of piling. This piling was placed many years ago. The piling is now in very poor condition and as it falls down, more and more of the dike is exposed to the wave action.

Area No. 9: Hansen Creek deposition, Section 17, Township 35 North, Range 5 East--Large amounts of gravel and silt are being deposited in the bed of Hansen Creek. A holding and settling pond is being considered for this stream.

Area No. 10: Highway 9 bridge bank erosion, Section 35, Township 35 North, Range 4 East--Left bank of Skagit River for about 2,000 feet downstream from Highway No. 9 bridge at Sedro Woolley is showing erosion and is considered a problem area.

Area No. 11: Channel change near Burlington, Section 34, Township 35 North, Range 4 East--Sharp bend just upstream and east of Burlington could cause a major channel change should a large flood of considerable duration occur.

Area No. 12: Gages Slough blocked drainageway, Township 35 North, Range 4 East--Gages Slough is probably an old channel of the Skagit River. Floodwater will enter this slough as State Highway 20 is topped. The effectiveness of this slough to carry floodwater is in question due to neglect, abuse, and undersized culverts. It would serve to help remove floodwater from the City of Burlington once the flood started to recede. With considerable work, Gages Slough could be improved both as a drainageway and floodway.

Area No. 13: Cockreham Island levee failures, Sections 15 and 22, Township 35 North, Range 6 East--Levee along east boundary of Cockreham Island has been topped in the last three major floods (1975, 1979, 1980) with major levee failures in 1979 and 1980.

Area No. 14: Hamilton flooding, Section 16, Township 35 North, Range 6 East--Hamilton has been flooded and evacuated in the three recent floods noted above. The entire town is in the floodway of the river.

Area No. 15: Section 10, Township 35 North, Range 7 East--Grandy Creek was rechanneled under a wood pile railroad bridge with pile lines at about 8-foot intervals just upstream of Highway 20. The restriction has caused a buildup of gravel and silt and a log jam problem at times of high water.

Each of the problem areas will be addressed in Chapter 8 in the discussion of prioritization.

Continuing Flood Control Projects

Existing flood control works are continually subject to high water and natural forces and must be continually monitored and maintained. These areas are inspected after every flood to determine rehabilitation needs. All known existing facilities are shown in Figure 2-3. Each of these areas should be considered a problem area:

- All existing dikes and levees require continual maintenance and, therefore, should be considered problem areas.

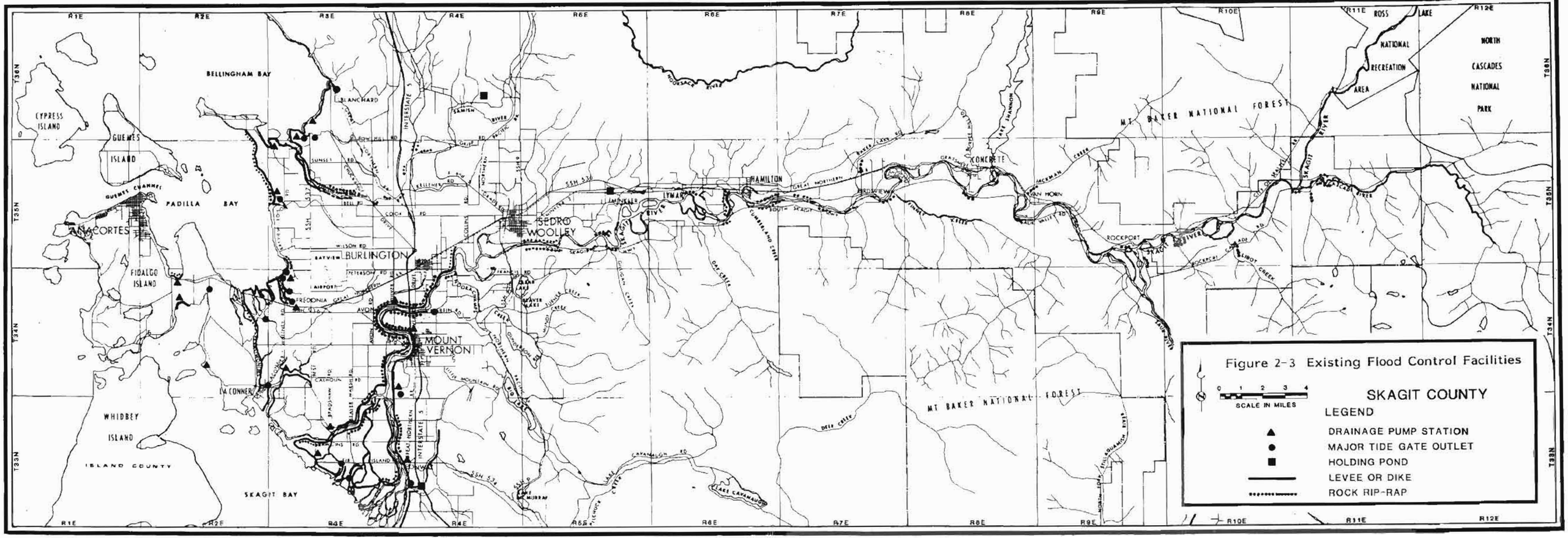


Figure 2-3 Existing Flood Control Facilities
SKAGIT COUNTY
SCALE IN MILES
0 1 2 3 4
LEGEND
DRAINAGE PUMP STATION
MAJOR TIDE GATE OUTLET
HOLDING POND
LEVEE OR DIKE
ROCK RIP-RAP
BELLINGHAM BAY
CYPRESS ISLAND
GUEMES ISLAND
GUEMES CHANNEL
PADILLA BAY
LA CONNER
FIDALGO ISLAND
WHIDBEY ISLAND
ISLAND COUNTY
SKAGIT BAY
BLANCHARD
SAMISH RIVER
BURLINGTON
SEDRO WOOLLEY
MOUNT VERNON
HAMILTON
CONCRETE
ROCKPORT
MT BAKER NATIONAL FOREST
ROSS LAKE NATIONAL RECREATION AREA
NORTH CASCADES NATIONAL PARK
SKAGIT RIVER
LAKE CAVANAUGH
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
R9E
R10E
R11E
R12E
T36N
T35N
T34N
T33N
T38N

- All existing rock riprap areas require continual maintenance and should be considered problem areas.

- All pump stations require continual maintenance and, in some cases, will require upgrading as drainage volume increases.

- All tide gate structures require continual maintenance and will, at some time, require upgrading or replacement.

Additional Problem Watch Areas

The above listed problem areas are known and are monitored frequently. There are other areas in the County that are subject to flooding problems when certain uncontrollable conditions exist. The exact location of future problems in these areas is impossible to predict, but the County, through past experience, has come to expect problems in these areas.

The areas downstream from timber lands have problems at times. The streams feeding down from the timber land for the most part follow a well-defined channel down the steep slope through the timber land then flow across a flat plain to the river. As the timber is removed, an increase in runoff and erosion occurs, causing large deposits of material in the channel of the flat plain.

The timber practices are the main contributors to flooding problems in the feeder stream areas. The increased flows in the small feeder stream subbasins are small in comparison with the Skagit and Samish River flows, and do not cause appreciable damage further downstream. The location of timber harvesting is frequently changing. In the past, the flood damage done in the feeder stream areas has been addressed and mitigated by flood damage reduction practices.

Both log and gravel deposits collect at various locations along the upper part of the river. It is not possible to predict exactly where the accumulations will occur year by year. The log jams and debris bars are in a constant state of change. As the bars and jams build, the main flow of the river is changed, causing erosion. In a number of cases, this erosion and bar buildup is to the point that a major channel change could occur. The debris accumulation must be cleared before it causes major problems.

CHAPTER 3

LEGISLATIVE RESPONSES

Various regulatory programs are in effect in Skagit County which affect both the need for flood protection works and the manner in which it may be carried out. Flood control works and protection is seen as a public benefit for the entire county. In general, Skagit County's regulatory programs take into account the benefit of flood control works and allow for them to be constructed, provided that they are well-designed, necessary, suitable, and potential impacts are mitigated. Other regulations control activities on the floodplain and shoreline so as to minimize flood damage potential.

Shoreline Management

The management of shorelines is regulated by the Skagit County Shoreline Management Master Program. The program was adopted by the County in June of 1976. The program is mandated by the State Shoreline Management Act (SMA, Chapter 90.58 RCW). The SMA is implemented by the local government under the oversight of the State Department of Ecology (WDOE).

The purposes of the program, as it relates to flood control practices, are as follows:

- To foster all reasonable and appropriate uses of the shorelines.
- To enhance public interest and allow limited reduction in public rights.

The natural character of the shorelines is to be preserved. State-wide interest is recognized over the local interest, as well as long-term over short-term benefit. Resources and ecology are to be protected while public access and recreational opportunities are also enhanced.

Shoreline definitions, area designations, and applicable management policy were developed for the county. Many of the general management policies potentially relate to flood control work. Some of the management policies include:

- New development should locate in under-utilized developed areas.

- Activities of low to medium intensity are preferred in the shorelines areas.

- Agricultural land is to be protected. Existing character and natural value of the shorelines should also be preserved.

The policy also states that all programs should be coordinated and monitored by applicable regulatory agencies, and should be in accordance with applicable comprehensive plans. Modifications and measures must be sited and designed by qualified personnel to comply with design standards.

Policies and regulations were more specifically developed for specific activities, including agriculture, dredging, forest management practices, landfills, recreation, and transportation facilities, as well as other items. The policies governing these activities are consistent with the general management policies. A sample of the policies pertaining to flood control work include:

- Dredging should not affect natural drainage, currents flows, or water quality.

- Forest practices are encouraged so long as they meet or exceed policies set forth in the Forest Practices Act.

- Landfills and transportation facilities as part of industrial development should be planned to minimize effects to drainage and floodwater.

- Recreational structures should be located out of the floodway to minimize the need for protective work.

A separate section (Chapter 7.16) is devoted to policies and regulations exclusively regarding shoreline stabilization and flood protection. General highlights of the section include:

- Programs must be coordinated and monitored to provide for comprehensive planning.

- Modifications and flood protection measures should be sited and designed by qualified personnel to comply with design standards.

Section 7.16 also provides policies and regulations governing design, location, materials, natural features, agricultural practices, and alternatives and impacts for stabilization and flood protection. Appendix B includes the section in its entirety. Some important policies listed include:

- Riprap and bank stabilization should be constructed to prevent damage to agricultural land, public roads, existing structures or natural features of public interest, not restricting the flow of the river.
- Projects should be located landward of natural wetlands, marshes, and swamps.
- No intensive land uses should be allowed within paths of meandering channels.
- Realignment and channel modifications are discouraged.
- Natural features should remain that do not intrude on channels, reduce flow capacity, or threaten structures.
- All works must allow passage of surface and ground water.
- A shoreline permit as required by RCW 90.58.140(1) is needed before commencement of stabilization or flood protection measures.

Drainage

Skagit County adopted its Water Drainage and Erosion/ Sedimentation Control Ordinance (Skagit Ordinance No. 9763, Chapter 14.36) in 1983 which potentially applies to flood control works. The purpose of the ordinance is to "promote sound development policies and construction procedures which respect and preserve the County's water courses; to minimize water quality degradation by controlling the sedimentation of drainage ditches, creeks, rivers, ponds, lakes, and other water bodies; to protect property owners adjacent to developing land from increased runoff rates which may cause erosion of abutting properties; to preserve and enhance the suitability of waters for active and passive recreation and sport and commercial fishing; to protect valuable ground water resources; to protect downstream property owners; to ensure the safety of County roads and rights-of-way; and to decrease surface water damage to public and private property." The ordinance requires a drainage plan for most property improvements that require a permit.

The ordinance has a supporting document, Procedure Manual for Drainage/Erosion/Sedimentation Control, which was also adopted in 1983. The manual contains design standards and other requirements for setbacks, discharge limits, detention, and erosion and sedimentation control.

Land Use and Zoning

Skagit County adopted the Zoning Ordinance (Chapter 14.04 Skagit County Code) in 1985. The purpose of the ordinance is to

assist in orderly development, conserve the value of property, and safeguard the public welfare by means of a comprehensive land use plan which is, in part, carried out by the provisions of the ordinance. It is further intended to provide regulations and standards which will:

1. Encourage the most suitable and compatible uses of land.

2. Provide residents adequate light, air, access, privacy, and safety from fire and other hazards.

3. Allocate sufficient lands for all required uses while conserving the County's agricultural and natural resources.

The ordinance protects the agricultural land uses and limits commercial and industrial uses to specified areas, mostly outside the floodplain. Current land use maps are included in Appendix C.

The ordinance has one provision which directly relates to flood control work. Section 19(12) requires that all structures have a minimum 50 feet landward setback from the toes of dikes and levees. The same section also lists additional requirements for owners in Skagit Beach Plats 1 through 5 in the East Swinomish Channel.

Resource Management

Resource management regulations are intended and designed to protect public resources such as water, fish, and wildlife, while allowing reasonable exercise of private property rights. Because structural flood protection measures are usually carried out within the stream or nearby in the shoreline zone, they have the potential to damage public resources.

Wild and Scenic Rivers Act. Section 703 of Public Law 95-625 (November 10, 1972) amended Section 3a of the Wild and Scenic Rivers Act to designate selected segments of the Skagit, Cascade, Sauk, and Suiattle Rivers for inclusion in the Wild and Scenic River System. The Act sets limitations on the degree and amount of construction and modifications that can be done to the river system. This legislation effectively precludes upstream storage on these river segments.

Forest Practices Act. The timber industry is a major economic entity in Skagit County. It also has an effect on flood problems, as forest practices can aggravate runoff through increased sedimentation, debris, volume, and velocity. The Forest Practices Act (Chapter 76.09 RCW) and the Forest Practices Board (Title 22 WAC) regulate the management of the resources, and the State enforces the regulations. The Act has mitigating measures to protect stream erosion.

Hydraulic Project Approval. The Hydraulic Project Approval (HPA) is issued by the State Department of Fisheries or Wildlife under the authority of the Washington Hydraulic Code (RCW 75.20.100) which requires the departments to regulate activities within the marine and fresh waters of the state. The Department of Fisheries exercises jurisdiction over marine waters. The two agencies share jurisdiction over fresh waters, though one agency will assume lead status over a specific fresh water body. The Department of Fisheries exercises jurisdiction over the Skagit River. Regulation is implemented in accordance with Hydraulic Code Rules (Chapter 220-110 WAC).

Therefore, any shore protection works such as dikes constructed waterward of the line of ordinary high water or instream work such as gravel removal conducted in Skagit County require an HPA.

The primary function of the Hydraulic Code is to protect the state's fisheries resources, including spawning and rearing habitat. Thus, the rules for gravel removal (WAC 220-110-140) limit the removal to gravel two feet above the current water level, prohibit the leaving of potholes, and require a maximum gradient on the excavated surface of two percent. The rules for bank protection work (WAC 20-110-050) limit such construction to stream banks actually damaged.

An HPA is required for both new construction and repair of old or damaged bank protection works. An approved HPA will ordinarily carry strict limitations on the time of year during which construction activities may be carried out. This is necessary to protect certain fish populations during critical phases of their life cycle.

HPAs for the Skagit River are administered by:

Habitat Management Section
Washington Department of Fisheries
3939 Cleveland Avenue
Tumwater, Washington 98504

Department of the Army Permit. The U.S. Army Corps of Engineers (the Corps) is required to regulate discharges of dredged and fill material into waters of the United States and associated wetlands under Section 404 of the Clean Water Act. This regulatory charge includes shore protection structures and any associated earthmoving and landfilling. The Corps is also required to regulate any construction within navigable waters under Section 10 of the Rivers and Harbors Act of 1899. The Corps has developed a consolidated permit application and review program for their responsibility under both laws, known as the Department of the Army Permit. Therefore, any shore protection structures constructed waterward of the lie of ordinary high water (or within

an associated wetland) will require a Department of the Army Permit.

Certain minor shore protection projects may come under the Corps' nationwide permit program, for which no formal permit application is required. However, notification of the Corps is required for certification of exemption from full permit application and processing requirements. Minor shore protection works eligible for the nationwide permit program are still required to meet certain minimal design and construction specifications. An exemption to the requirement for a full permit application and processing under the nationwide permit program may be obtained if the proposed shore protection work complies with the following criteria (33 CFR 330.5 [a] [13]):

1. The proposed shore protection is less than 500 feet in length;

2. the project is necessary for erosion protection;

3. the filling within waters of the United States is limited to less than one cubic yard per running foot of shore protection;

4. no material is placed in excess of the need for shore protection;

5. no material is placed in a wetland;

6. no material is places so as to impair surface water flow into or out of a wetland;

7. only clean fill free of waste metal products, organic materials, unsightly debris, etc., is used; and

8. the proposal is for a single, complete project.

The Department of the Army Permit program is administered by:

Regulatory Functions Branch
Seattle District
U.S. Army Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Water Quality Certification. The Washington Department of Ecology administers the state Water Pollution Control Act (Chapter 90.48 RCW) in accordance with the Water Quality Standards for Waters of the State of Washington (Chapter 173-201 WAC).

Stream bank protection and instream gravel removal has the potential to create temporary instream turbidity in excess of

state water quality standards during the construction period. The Water Quality Standards provide for short-term modifications of the standards "when necessary to accommodate essential activities, respond to emergencies, or to otherwise protect the public interest" (WAC 173-201-035 [8] [e]).

Stream bank protection and instream gravel removal projects require a Water Quality Certification including a short-term modification of pertinent water quality standards. Each such certification is reviewed and issued on an individual basis as an administrative order, and includes specific limitations on how and when construction activities may be carried out. For projects which also require a Department of the Army Permit, application for a Water Quality Certification should be made to:

Environmental Quality Section
Northwest Regional Office
Washington Department of Ecology
7272 Cleanwater Lane
Olympia, Washington 98504

For projects not requiring a Department of the Army Permit, application for a Water Quality Certification should be made to:

Environmental Review Section
Washington Department of Ecology
Olympia, Washington 98504

Flood Control and Floodplain Management

A number of programs relate to flood control or floodplain management. Some are intended to regulate certain activities (e.g., land use) to limit the effects of flooding. Others are non-regulatory programs intended to coordinate and finance public flood control measures.

National Flood Insurance Program (NFIP). The NFIP is described in detail in a publication available from the Shorelands and Coastal Zone Management Program of the WDOE (Floodplain Management Handbook for Local Administrators; Floodplain Management Section, 1986). The following is a summary of the program.

The NFIP was established in 1968 to make flood insurance available for residential and non-residential structures. The NFIP has two central purposes. First, by making flood insurance available, Congress felt that it could alleviate the financial burden and general economic distress resulting from both chronic and disastrous flooding. Second, Congress also had the goal of mitigating floodplain actions which would cause a financial drain on the national treasury. The basis of operation of the NFIP is an agreement between the County and the Federal Emergency

Management Agency (FEMA), the federal agency which administers the program. After FEMA confirms the County as "flood prone" the County becomes eligible to have flood insurance coverage made available. The County must adopt and enforce floodplain management regulations in accordance with the minimum criteria of FEMA.

In 1984, FEMA completed a flood insurance study for unincorporated Skagit County, as well as for Concrete, Hamilton, LaConner, Lyman, Anacortes, Burlington, Mount Vernon, and Sedro Woolley. The 100-year floodplain for the entire watershed within the County was determined through hydraulic and hydrologic analyses performed by the Corps of Engineers and Dames and Moore for FEMA. Flood insurance rate maps were developed for the flood-prone areas determined in the study. The 100-year floodplain is the boundary of the designated flood-prone areas. The area map presented in Figure 3-1 shows the location of the 100-year floodplain.

Floodplain Management Regulations. Skagit County adopted floodplain management regulations in April 1987 in accordance with the minimum FEMA requirements, in order to remain eligible for the NFIP.

Ordinance No. 11216 modified the existing Title 15, Chapter 15.20 Skagit County Flood Damage Prevention Ordinance to incorporate the new federal regulations for the NFIP that went into effect October 1986. The general purpose of the ordinance is to minimize public and private losses due to flood conditions in specified areas. This ordinance has the effect of being a building code for floodplain construction. In order to accomplish this purpose, the ordinance includes methods and provisions for:

1. Restricting or prohibiting uses which are dangerous to health, safety, and property due to water or erosion hazards, or which result in damaging increases in erosion or in flood heights or velocities.

2. Requiring that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction.

3. Controlling the alteration of natural floodplains, stream channels, and natural protective barriers, which help accommodate or channel floodwaters.

4. Controlling filling, grading, dredging, and other development which may increase flood damage.

5. Preventing or regulating the construction of flood barriers which will unnaturally divert floodwaters or which may increase flood hazards in other areas.

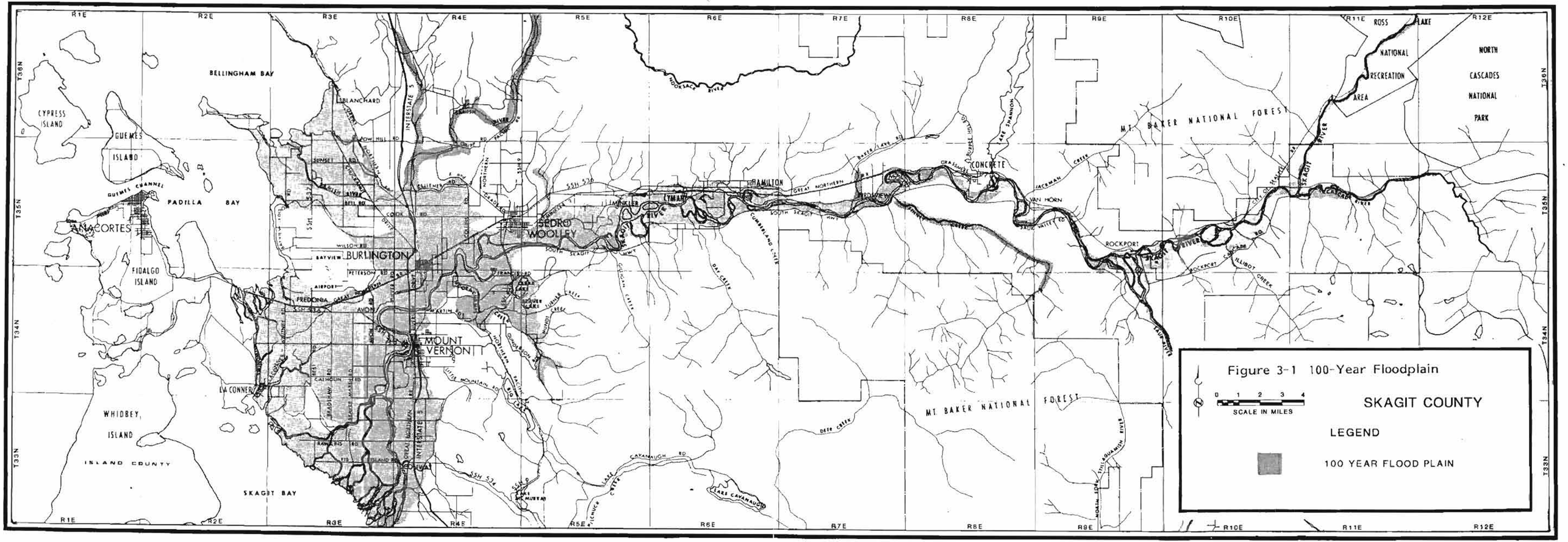


Figure 3-1 100-Year Floodplain
SKAGIT COUNTY
SCALE IN MILES
0 1 2 3 4
LEGEND
100 YEAR FLOOD PLAIN
BELLINGHAM BAY
CYPRESS ISLAND
GUEMES ISLAND
GUEMES CHANNEL
PADILLA BAY
ANACORTES
FIDALGO ISLAND
WHIDBEY ISLAND
ISLAND COUNTY
SKAGIT BAY
BLANCHARD
BURLINGTON
SEDRO WOOLLEY
MOUNT VERNON
LA CONNER
INTERSTATE 5
HAMILTON
CONCRETE
ROCKPORT
MT. BAKER NATIONAL FOREST
ROSS LAKE NATIONAL RECREATION AREA
NORTH CASCADES NATIONAL PARK
SKAGIT RIVER
SAUK RIVER
NOOKSACK RIVER
LAKE CAVANAUGH
T38N
T35N
T34N
T33N
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
R9E
R10E
R11E
R12E

Standards are specified that help to minimize flood damages. Anchoring of buildings in the floodway is required, as well as flood-proofing. The first floor is required to be one foot above the base flood elevation, and all utilities are to be flood-resistant. Other specifications are also listed in the ordinance.

Flood Plain Management. The Flood Control Zone Act was first enacted by the state legislature in 1935 for the "alleviation of recurring flood damages to public and private property, to the public health and safety, and to the development of the natural resources of the state . . ." (RCW 86.16.010). The Act originally specified state regulatory authority over designated flood control zones, including the authority to regulate construction and planning within floodplains and floodways (RCW 86.16.020, 025).

Skagit County has eight subflood control zones which are affected by the changes in the Act. The locations of these control zones are shown in Figure 3-2.

In June 1987, the legislature retitled Chapter 86.16 RCW to Flood Plain Management and enacted substantial changes to the Act (ESB 5556). The revised act shifted basic regulatory authority from the state to local government, eliminated the state designated flood control zones, and extended authority of the Act to the entire state, not just the designated flood control zones. The state retained oversight authority over the actions of local governments in implementing the new Act. The DOE provides technical assistance to local governments, and must approve locally prepared floodplain management programs. New rules for implementation of the Act (WAC 173-158, Flood Plain Management) have been developed by WDOE and were adopted May 3, 1988.

Diking and Drainage Districts. Title 85 RCW authorized the formation of diking and drainage districts. These districts are given responsibility over dikes and drainage systems, may petition the County for funding and assistance, and can assess those within the district that are receiving benefits. Local control of diking and drainage is maintained, yet proper permit application and review procedures are required to prevent piecemeal flood control projects that might be inconsistent with resource management regulatory programs. Skagit County presently has 25 diking and drainage districts, as shown in Figure 3-3.

Coordination

There are no institutionalized programs for comprehensive coordination of land use and flood control regulations or permit processing at either the state or local government level. Informal coordination occurs between the state DOE and Department of Fisheries regarding comprehensive flood control management planning.

Four permits are potentially necessary to carry out structural flood control work:

1. A federal Department of the Army Permit, a consolidation of the Section 10, Rivers and Harbors Act, and Section 404, Clean Water Act permits, is necessary for work carried out in navigable waters, waters of the United States, and adjacent wetlands.

2. A state HPA is necessary from the state Department of Fisheries for work in or near fish-bearing waters.

3. A local Shoreline Substantial Development Permit, under the state Shoreline Management Act, is necessary for work in and within the wetlands adjacent to streams with an average annual flow of 20 cfs or greater.

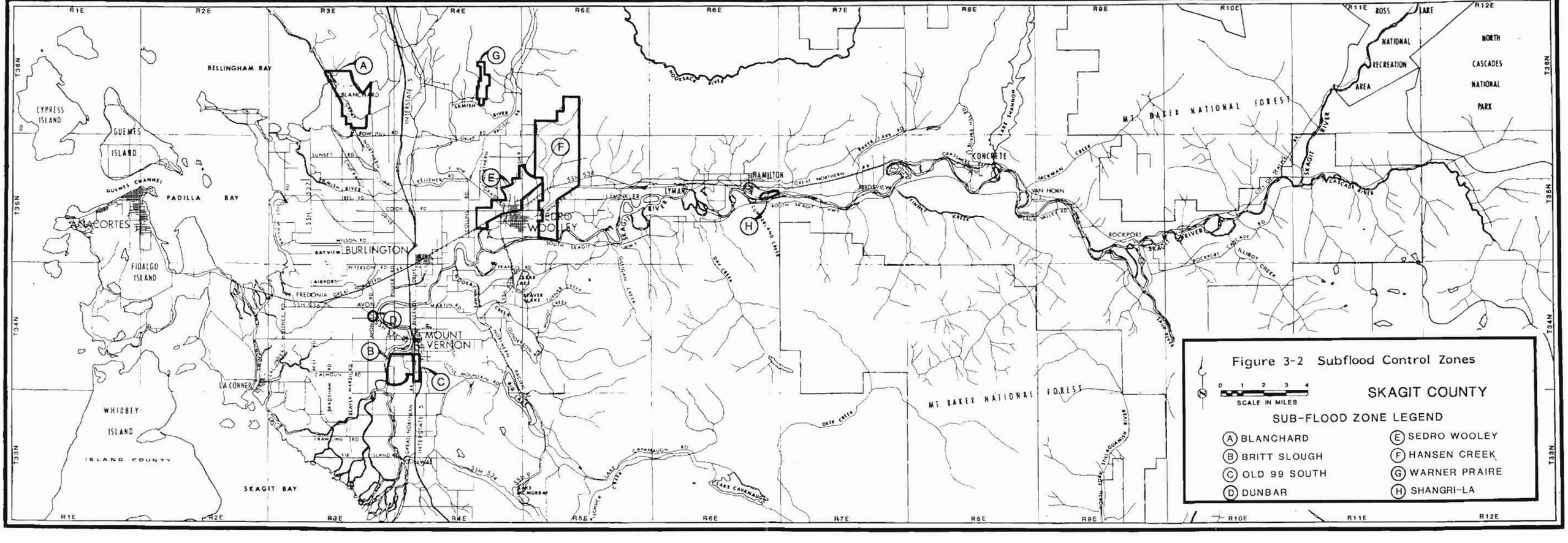
4. A local permit is necessary for construction within the 100-year floodplain.

The state's Environmental Coordination Procedures Act (ECPA) process is voluntarily available to permit applicants through the DOE's Environmental Review Program for coordination of state permits, but this does not include coordination of federal permits. Coordination is considered necessary to avoid contradictory conditions of permit approval by different agencies with different regulatory mandates.

Interagency Stream Corridor Management Guidelines were promulgated in 1985 as an interagency memorandum of understanding (MOU) between the Washington Departments of Game, Fisheries, and Ecology, the Washington Conservation Commission, and the U.S. Soil Conservation Service. The guidelines establish a procedure for interagency cooperation and coordination in the planning, design, and implementation of structural and non-structural works and activities within stream corridors, including permit review. The contact persons under the MOU for the Skagit River basin are:

Department of Fisheries

Regional Habitat Manager
Habitat Management Section
Washington Department of Fisheries
3939 Cleveland Avenue
Tumwater, Washington 98504


R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
R9E
R10E
R11E
R12E
T36N
T35N
T34N
T33N
T38N
BELLINGHAM BAY
CYPRESS ISLAND
GUEMES ISLAND
GUEMES CHANNEL
PADILLA BAY
ANACORTES
FIDALGO ISLAND
WHIDBEY ISLAND
ISLAND COUNTY
SKAGIT BAY
BURLINGTON
MOUNT VERNON
SEDRO WOOLEY
LA CONNER
HAMILTON
LYMAN
CONCRETE
ROCKPORT
MT. BAKER NATIONAL FOREST
ROSS LAKE NATIONAL RECREATION AREA
NORTH CASCADES NATIONAL PARK
SKAGIT RIVER
SAMISH RIVER
NOOKSACK RIVER
INTERSTATE 5
A
B
C
D
E
F
G
H
Figure 3-2 Subflood Control Zones
SCALE IN MILES
SKAGIT COUNTY
SUB-FLOOD ZONE LEGEND
A BLANCHARD
B BRITT SLOUGH
C OLD 99 SOUTH
D DUNBAR
E SEDRO WOOLEY
F HANSEN CREEK
G WARNER PRAIRE
H SHANGRI-LA

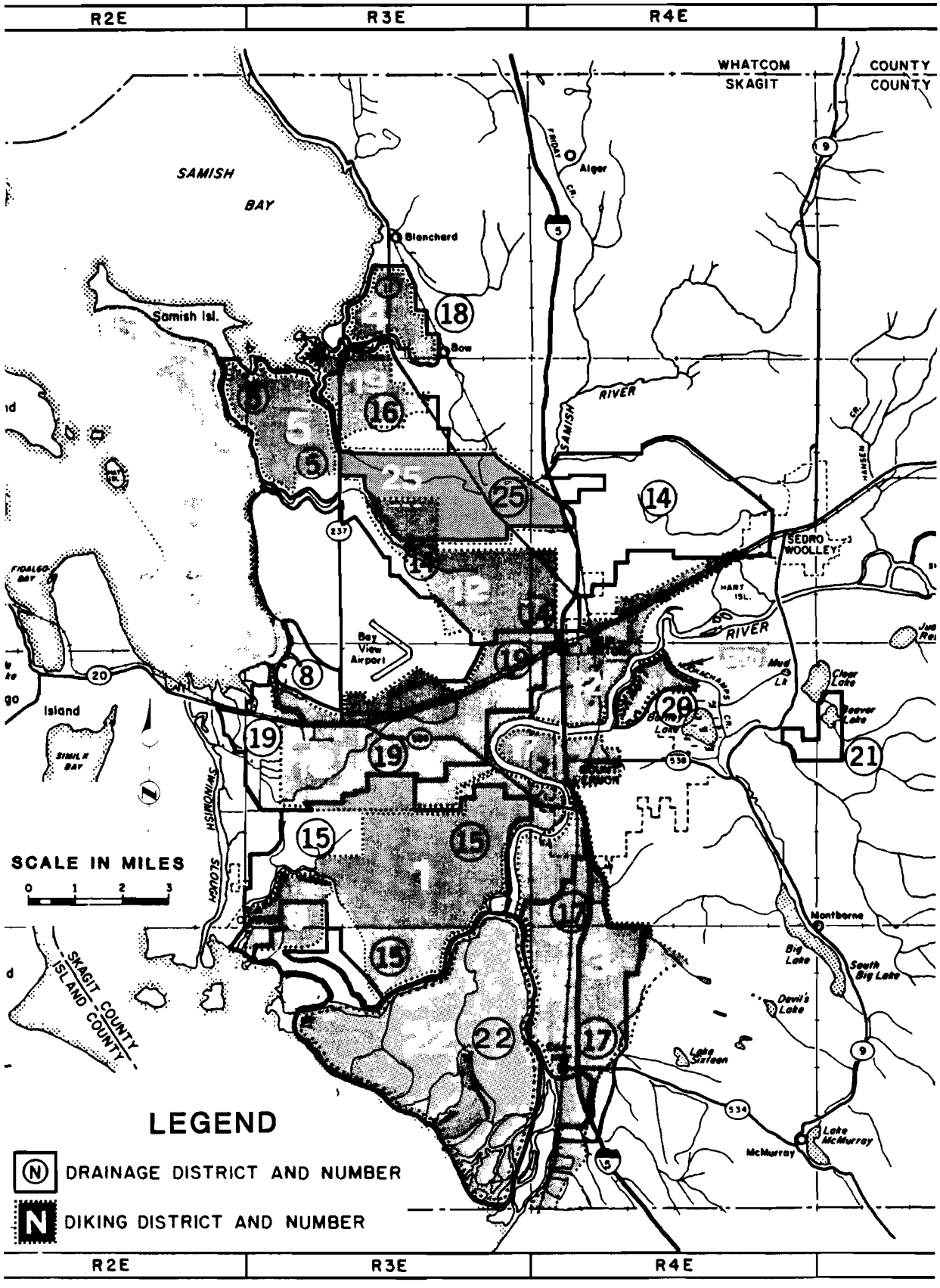


Figure 3-3 Drainage and Diking Districts

Department of Ecology

Water Quality

Northwest Regional Office
Washington Department of Ecology
7272 Cleanwater Lane
Olympia, Washington 98504

Shoreline Management

Management Section
Shorelands and Coastal Zone Management Program
Washington Department of Ecology
Olympia, Washington 98504

Skagit County Conservation District:

District Conservationist
Skagit County Conservation District
816 East Fifth Street
Olympia, Washington 98501

U.S. Soil Conservation Service

Olympia Field Office
816 East Fifth Street
Olympia, Washington 98501

CONSTRAINTS ON INSTREAM FLOOD CONTROL

Flood control is seen as a public benefit by Skagit County. Most flood control work is permitted on a conditional use. The regulations as set forth above recognize the need for flood control work and provide the ways and means for these to be accomplished for maximum public benefit.

Some types of instream flood control work are inconsistent with regulations within the County. Legal, financial, public policy, social, economic, and environmental factors and conditions can impose constraints and limitations on the planning process. Possible constraints that were identified are listed below.

- The financial capabilities of Skagit County to fulfill the local cooperation requirements for flood control could constrain the scope of projects considered.

- Congressional passage in October 1978 of the Wild and Scenic Rivers legislation, which included large segments of the Skagit, Sauk, Cascade, and Suiattle Rivers in the national system, effectively precluded upstream storage on those river segments and thereby limited the flood control measures available for selection.

- Channel modifications are avoided to preserve natural functioning of the river. The Avon bypass project proposed by the Corps of Engineers in 1963 was never approved, due in part to such reasoning.

- The presence of important anadromous fishery resources in the Skagit River and significant wildlife resources in the Skagit River system, including waterfowl, shorebirds, and raptors, imposes some constraint on the types of solutions that could be considered to address the flood damage reduction objective and on specific design details.

- The large existing economic investment in the floodplain, including residential and commercial developments, and the high existing flood damage associated with these developments, could constrain the types of alternative solutions that could be economically or socially acceptable. This constraint could particularly affect the viability of some purely non-structural solutions such as permanent floodplain evacuation.

- Executive Order 11988 on floodplain management required federal agencies to provide leadership and take action to reduce the hazards and risk of flood loss; minimize the impact of floods on human safety, health, and welfare, and restore and preserve the natural beneficial floodplain values. The Executive Order constrains unnecessary development of floodplains and provides objectives to guide necessary floodplain development. It requires an analysis of possible non-structural measures which could be used instead of the traditional structural solutions.

- Executive Order 11990 on the protection and preservation of wetlands instructs all federal agencies to develop priorities and guidelines to protect wetland areas.

- The desires of the local sponsor and the communities along the Skagit River formed a constraint on the project design and the scope of improvements.

CHAPTER 4

GOALS AND OBJECTIVES FOR AREA OF COVERAGE

Given a history of flooding problems and known potential flood problem areas and damage potential, a strategy should be developed to address the County's flooding problems. A specific area must be identified over which the strategy will apply for comprehensive analysis. Goals and objectives for the specific area of coverage have been determined as part of this plan.

The previously stated regulations discussed in Chapter 3 of this plan each had purposes, goals, and objectives related to the mitigation of flood damages. A compilation of these purposes suggests that the objective of the comprehensive flood control management plan should be to promote public health, safety, and general welfare by providing a comprehensive plan which addresses flood control problems and solutions in Skagit County consistent with existing policies and regulations. To attain this objective, the following short- and long-term goals should be achieved with the program.

FLOOD CONTROL PLAN GOALS

Short-Term Goals

1. Reduce threat to life and property. Attend to all known imminent flood hazards to the extent possible. Keep stream channels free from debris. Provide immediate spot improvements in areas of serious flood problems which cannot wait for comprehensive changes in the system.

2. Protect economic base. Maintain flood control works which enable agricultural lands and industries to function effectively. Retain viability of agricultural land and provide for winter crop cultivation.

3. Provide effective emergency response. Ensure emergency vehicle movement and emergency service access. Train and mobilize response teams. Provide timely repair and maintenance of damaged structures and services.

4. Maintain existing flood control structures. Develop and continue to improve program of scheduled maintenance of levees, riprap dikes, pump stations, and tide gates. Prevent failure during high water periods.

5. Maintain local control of flood control works. Encourage development of sub-flood control zone and diking districts. Continue cooperation and assistance programs with the districts. Maintain districts' independence and contract for services.

6. Efficient use of public dollars. Public and project benefits are to exceed costs. Favor inexpensive, low-tech, and non-structural solutions. Apply for grants and funds for eligible projects which provide matching funds.

Long-Term Goals

1. Increase integrity of flood control facilities. Uniform flood protection based on elevation and integrity is the County's long-term priority. A 25-year flood frequency protection is the desired goal.

2. Reduce and prevent flood damage. Reduce average annual expenditures for flood control maintenance and capital improvement projects.

3. Maintain instream uses and resources. Retain wetlands and stream corridors to maximum extent possible. Preserve national streams and lakes as public amenities. Mitigate impacts to fish, wildlife, water quality, existing recreation, scenic, aesthetic, and historic resources.

4. Use equitable and stable financing. Develop equitable financing to pay for ongoing flood control work and capital improvements. Funding should be simple and easy to administer. Should charge according to contribution to problem. Create a pool for capital improvements.

5. Maintain safe transportation. Reduce traffic hazards. Enhance emergency vehicle movement. Provide safe, adequate, diversified, and compatible means of travelling and transporting goods and services during high water periods.

6. Develop systematic approach to flood control work. Provide consistent guidelines, adhering to all regulations, to meet communities' desires. Coordinate agencies, policies, and programs to best serve private and community concerns. Improve efficiency and implementation processes, updating when necessary.

7. Provide County-wide protection. Strive to provide equal flood protection for all portions of Skagit County. Avoid measures that will severely impact other areas in the county.

8. Pursue and support any feasible existing or future large scale flood control projects. This would include major projects such as additional upstream storage, major levee improvements, and diversion by artificial channel.

These goals and objectives best describe the County's approach to floodplain management. Proposed in-stream flood control work should be consistent with these goals and objectives.

AREA OF COVERAGE

In order to effectively accomplish these goals and objectives, a specific area of coverage must be identified over which flooding problems are evaluated comprehensively. The County and FEMA recognize that the majority of flooding problems occur in the 100-year floodplain, as established on the flood insurance rate maps (FIRM) and presented in Figure 3-1. All of the documented flooding problems discussed in Chapter 2 occur within this boundary. For this reason, the area the comprehensive plan will cover includes the 100-year floodplain as established by FEMA in the Skagit and Samish watersheds.

CHAPTER 5

FLOOD CONTROL MANAGEMENT OPTIONS AND ALTERNATIVES

Skagit County has many flood control options to choose from to mitigate the impacts of flooding. Due to the complex nature of the flooding, several methods of flood control are understandably necessary to accomplish a desirable measure of protection. The County has used several different flood control methods throughout its history and has been successful in controlling flood damages. This chapter discusses the flood control management options, both structural and non-structural, available to the County, noting the practices that have been used in the past, and those which may be viable today.

STRUCTURAL MEASURES

Structural measures for flood control management are measures which attempt to modify the flooding itself. Typically the control is in-stream or very nearby. Options for mitigating damage through structural measures include levees and dikes, coastal control, flood storage, channel maintenance and modifications, and control of contributing runoff areas. Each option has different capital expenditure and maintenance needs, and is best applied under certain conditions.

Levees and Dikes

Levees and dikes protect a specific portion of the flood plain from flooding by placing a barrier between the flood waters and the protected lands. These structures are usually earth filled, have sloped sides, and are protected from erosion by rip rap or revegetation. Existing levees and dikes in Skagit County vary in height from 5 to 10 feet, with a top width of 3 to 12 feet.

Levees and dikes are effective structural measures of protecting large areas of land and property. They remove a relatively small amount of land from otherwise beneficial uses and have few impacts on natural resources. The capital and maintenance costs are higher than other control measures, but the benefits are substantial if the project protects a large area.

New levees have the potential of increasing flood heights elsewhere by reducing the amount of flood plain available for flood storage. By concentrating flood waters in a smaller channel, the water velocities are increased and can aggravate

erosion problems unless mitigated with a good bank maintenance program. Drainage pumps are normally used to remove storm water that collects behind the levees, which have ongoing operational and maintenance costs as well.

Levees have been constructed in the lower reaches of the Skagit river since the early 1890s. In the beginning the levees were low and some areas were unprotected. The levees have since been raised and expanded to confine floods with a 8- to 25-year frequency to the river channel. More than 80 miles of levees and dikes are now in existence along saltwater bays and channels, along the main river channels between Skagit and Padilla Bays and Burlington. Eleven diking districts maintain the levee system which protects about 45,000 acres of land.

Additional levees could probably be used upstream of Burlington, where little flood protection currently exists. Additional levees could increase flood levels in unprotected areas, though. The entire existing levee system could be strengthened and raised to achieve the desired 25-year flood frequency level of control. To provide for emergency repair and services access, many of the levees need raising and widening.

Coastal Control

Saltwater flooding problems can be controlled by the use of dikes, flood walls and bulkheads, or tide gates. Dikes are constructed out of river materials and are earth filled. Flood walls and bulkheads are vertical sided structures usually made out of reinforced concrete, but can also be wood pilings. Large rip rap can also be used to construct a bulkhead. Breakwaters can be built to protect these structures from excessive wave damage. Flood gates (or tide gates) allow storm drainage to pass into the bays through the saltwater dikes . The gate prevents saltwater from traveling upstream during high tide and allows passage of storm water at low tide. Drainage pumps may assist the removal of water from behind the dikes. Each of these structures serve to protect the upland from the highest book tides.[a]

Almost the entire westerly boundary of the County is salt-water diked. Most of the dikes have been rock rip-rapped. The dikes are constructed to accommodate book tides only, and when high winds and low barometer readings accompany the high tides, overtopping occurs in several places, including LaConner and Edison. The dikes could be strengthened and raised. The break waters, tidegates and drainage pumps require continual maintenance, and may require removal and replacement.

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[a]A book tide refers to the tide predicted from tidal charts for the location.

Flood Storage

Flood water storage is the most direct means of flood water control. It is also the most versatile as the approach reduces the flood flow rate and peak rate, reduces the area inundated, and controls the duration of the flood. The degree of protection is dependent on the type of flood storage device and the storage capacity. Flood control storage can be attained with dams and reservoirs, holding ponds or sedimentation basins, or property acquisition of inundated lands.

Dams and Reservoirs. Hydropower projects on upper reaches of the river offer multi-use facilities for power, water supply and flood storage capacity. There are currently three dams on the Skagit river (Ross, George and Diablo) and two on the Baker River, which is a tributary to the Skagit. The dams provide a total of 193,000 acre-feet of flood storage, and control about 30 percent of the Skagit basin's runoff. It is estimated that since 1953 when the first dam was installed that flood crests at Sedro Woolley have been reduced by about 10 percent.

Additional large scale dams and reservoirs are no longer a flood control option for Skagit County. Sites have been proposed for the Suiattle and Sauk Rivers, but the Wild and Scenic Rivers Act placed limitations on construction and modification of these river systems, effectively prohibiting additional storage projects from being constructed. Environmental and economic concerns present almost insurmountable problems.

Holding Ponds--Settling Basins. Feeder streams have the tendency to leave the stream channels and flow over nearby fields at the point where the stream gradient is reduced as it approaches the flood plain of the river. Silt and debris are deposited as the velocities are reduced. A basin with a controlled outlet constructed at the point of gradient change can control the flooding and debris problems.

The holding ponds serve three purposes: the velocity of the stream is reduced, allowing the gravels and silt to settle out in a controlled area; energy is dissipated, which helps keep the stream in the channel downstream, and; some flood storage can be provided. The amount of flood storage offered by the facility would depend on its size.

The County has constructed two holding ponds at Coal Creek and Warner Creek to control stream bed deposits which contribute to flooding problems. The ponds have been successful in controlling the sediment problems, and have the benefit that they can be maintained in non-emergency periods. The material removed yearly from the ponds is available for use by the community as fill material.

Opportunity to use this method of flood control avails itself at several other feeder streams, including Hansen and Muddy Creeks. The facilities could also be sized to offer some limited flood storage capacity, if the siting and situation warrants it. Settlement basins are a relatively new approach to flood control within the County. The biggest problem with this option is setting up an authority to maintain and operate these structures. Final decisions are at the discretion of local property owners, and their desires determine the feasibility of the project.

Floodway Acquisition. Areas which experience frequent inundation and cannot economically be protected with flood control works may be candidates for acquisition. These lands would continue to act as a natural storage area for floods. The land can then be used as public parks or recreational facilities. Structures within the area would need to be removed or flood-proofed.

The Nookachamps area currently is unprotected by levees from flooding. This area of about 5000 acres floods during high Skagit River flows, and provided 34,000 acre-feet of storage in the 1951 flood. This added natural storage has given some relief to lower Skagit flooding.

Other areas within the meander belt of the Skagit River between Burlington and Marblemount are often inundated during high water. The feasibility of protecting these areas is low as they are in the almost direct run of the river. Some of these areas could be acquired if additional action is required.

Channel Maintenance and Modification

The purpose of channel modification and maintenance is to preserve or increase the flood capacity of a specific stream reach. Maintaining and enhancing existing flow patterns keeps flooding from occurring in new areas and helps to convey the flow as efficiently as possible. Many techniques can be used to enhance channel performance including bank stabilization, debris removal, realignment and removal of restrictions, flow diversions or bypass, and enlargement or dredging.

Bank Stabilization and Erosion Control. The natural tendency of the river in the flood plain is to meander, which causes erosion in some areas and depositing of those materials in other areas. High flows during flood events within the channel area have increased velocities and tend to erode more material away. Structures such as roads and levees along the river's edge need to be protected from extensive erosion which might cause a levee failure, channel change or road collapse.

Several materials can and have been used by the County to control erosion on the stream embankments. Rock rip-rap is the most common. It is an abundant supply up the river, is natural looking and does an excellent job in maintaining the banks. Revegetation is used in moderation; sod and grasses are placed and maintained on all the levees and dikes, but plants which have a potential to become dislodged during a flood event or are very difficult to maintain are avoided. Revetments and piling have been used in the past, but are capital intensive to build and difficult to repair once deteriorated. Gabions and vegetative cover would not perform well in high velocity flows experienced in the Skagit River, but may have merit on a smaller stream. The use of rubble or asphalt as bank stabilization is not allowed by the County.

Debris Removal. Log jams, snags and stumps have a tendency to collect at restrictions, bends, or anywhere else there might be an corner or high spot in the river to become lodged against. High velocity flows through a debris accumulation can cause serious erosion problems, and the back waters created by the capacity reduction can be substantial. The County has and will continue to remove debris in areas that have flood damage potential. Non-threatening natural debris is retained so as to maintain shade and organic material for the fisheries resources.

Realignment or Removal of Restrictions. At times the natural meandering of the river encroaches on existing structures. Realigning the channel can prevent damage on the short-term at that location. Channel straightening counteracts the natural tendency for gradient reductions in the stream. It will increase velocities through the section, which will tend to make downstream erosion problems worse. For this reason the County does not undertake realignment projects and this option will not be considered further.

The removal of restrictions has the benefit of increasing channel capacity and reducing the tendency of debris accumulations. Often the restrictions are bridges, which take major expenditures to modify. The restriction on a small feeder stream may be misaligned or undersized culvert, which in comparison, can be remedied fairly inexpensively.

Flow Diversion or Bypass. High flow diversions typically direct flood flows around developed areas and from a main channel into natural or artificial secondary channels or conduits. Physical opportunities for flow diversion are often limited by the lack of appropriate lands through which to divert the flows.

Although no flow diversions have been constructed in the Skagit Basin, the option has been considered. The Flood Control Act of 1936 authorized the Avon Bypass Project for the partial control of floods in the lower Skagit Valley. The proposed bypass

channel would divert excess Skagit River flows from Burlington to Padilla Bay, a distance of about five miles. The project has not been undertaken as Skagit County has not been able to meet local participation requirements. Substantial costs would be involved in the relocation of transportation facilities and the acquisition of right of way. Still, this is an option open to the County. The Avon bypass will not be considered further in this plan as the project study reports (Corps of Engineers, 1963) contain the necessary impact and alternative analysis, and can be referenced if desired.

Old meander ways can also be used for high flow diversions and flood storage. Gages Slough is probably an old channel of the Skagit River and could be used to help remove water from Burlington once a flood started to recede. Currently, the sloughs effectiveness in carrying flood waters is in question as it has been neglected, abused and has undersized outlet capacity. The slough could be improved as a drainage way and flood way.

Enlargement and Dredging. Enlargement of a stream section can increase flow capacity and in-stream storage. Dredging is often used to accomplish this purpose, removing aggradation materials from the river bed. Enlargements efforts usually have short lived effectiveness, as materials removed during low flow periods are replaced during winter peak flows.

Dredging is used by the County to remove gravel accumulations that have built up to the point where a major channel change could occur. Dredging has occurred more frequently on the feeder streams. Gravel deposits occur at the point of gradient and velocity reductions, causing buildups and restrictions. Dredging the material removes the problem buildups and prevents it from travelling downstream.

Control of Contributing Area

Control of the runoff from contributing areas into the basin can mitigate flooding problems by decreasing the rate and amount of storm runoff, and by allowing quick and efficient removal of the water. Methods of controlling runoff include measures that affect infiltration, storage and conveyance of the flows.

Increase Infiltration. An increase in the ground's capacity to soak up the water reduces the amount of excess surface water runoff available to cause flooding. Optimizing the infiltration usually includes measures to maximize the retention of vegetation, particularly forests, and minimize the development of impervious surfaces such as buildings and roads. Land treatment is most effective in small basins or headwaters, and has the biggest impact on low level flooding.

The forested areas within the County have the largest impact on the runoff peaks and volumes. The sudden decrease in infiltration when a forested area is harvested causes increased flow and erosion problems. The State regulates the forest practices through the Forest Practices Act, and requires mitigation measures in harvesting areas. The County has little additional control over the hydrologic impacts of harvesting.

Drainage ordinances can influence the infiltration within urban or developing areas. In suitable areas, drain tiles or rock pits could be used to put the storm runoff into the ground, versus conveying it into a storm drain. Grass-lined detention ponds, pervious surfaces for parking lots, and terracing slopes can improve infiltration and reduce storm runoff. The County could consider including such measures in a drainage ordinance, if the necessity arose.

On-Site Detention. On-site storm water detention has become a standard practice in many urban areas for the purpose of moderating the effect of flood flows up to the 10 to 25 year storm; on-site detention of larger storms becomes increasingly difficult and costly. On-site detention provides temporary storage of storm water for delayed release, thus reducing peak flows.

Skagit County Water Drainage and Erosion/Sedimentation Control Ordinance requires retention/detention facilities for substantial developments, unless it can be demonstrated that no adverse impact will result without it. The purpose of the facility is to regulate the discharge rate at or below the existing design storm's peak discharge. As the ordinance provides for runoff control through on-site detention, no additional consideration of this alternative is required.

Conveyance. Localized flooding problems are created when the storm water is not carried away at the same rate that it accumulates. Undersized or poorly maintained facilities not only create localized problems, but can cause increased duration of the problems if the flows are not conveyed before the river rises in height.

Conveyance systems are maintained to reduce local flooding problems. Conduits, channels (natural or lined), ditches, and culverts may be used to improve parts of the conveyance system. Existing storm drains, culverts and ditches can be cleaned and improved within the County to improve drainage and flooding potential.

Summary of Structural Alternatives

The methods of controlling floods through in-stream control are many and diverse. The County has used nearly all of the measures, with the exception of floodway acquisition. Almost all of the measures described are consistent with regulations and policies governing flood control work, and are still viable options open to the County. Those options that will not be considered due to regulation conflicts, ineffectiveness, or adequate existing regulation are dams, realignment, and on-site detention.

NON-STRUCTURAL ALTERNATIVES

Non-structural flood control measures attempt to modify the effect of flooding, rather than modifying the flooding itself. The primary focus of non-structural measures is to modify human actions and behaviors which will reduce flood damages. Non-structural measures include modification of development policies and land use regulations, risk management in flood prone areas, enhancing flood plain management, and improving emergency response systems. These measures can be used alone, or in conjunction with the structural measures previously discussed.

Development Policies and Land Use Regulation

Policies and regulations can be developed to prevent or discourage people from unwise actions or land uses in flood prone areas. These measures usually affect one or two structures at a time as they are being developed and limit the location and type of development that can occur. Many of the County's policies and regulations discussed have been responses to state laws on policies regarding actions in the flood plain.

Flood Plain Management Regulations. Management of the flood plain is necessary, not only for the locations that experience flooding, but for the welfare of the entire state. For that reason, several state laws have been enacted which manage activities in the flood plain. One such law is the Flood Plain Management Act (Chapter 86.16 RCW). The act regulates construction and planning within the floodways and flood plain.

The Federal Emergency Management Agency (FEMA), and the National Flood Insurance Program (NFIP) are national agencies and programs which effect flood plain management. In order to have flood insurance coverage made available from the NFIP, the County had to adopt flood plain management regulations consistent with FEMA requirements. The County adopted its Flood Damage Prevention

Ordinance #11216 in 1986 to comply with the regulations. This ordinance has the effect of a building code for flood plain construction and preserves the natural function of streams.

The County's compliance with the NFIP, and the other state policies concerning flood plain management, form a complete regulatory framework that helps protect the County from increases in flood damage. No additional flood plain management regulations need be considered.

Drainage Ordinance. Storm water from the urbanized areas which contributes to flooding problems must also be controlled. Control of urban storm water can be accomplished through the use of a drainage ordinance. The drainage ordinance would require permitting of larger developments, ensuring proper handling of storm run-off.

The County adopted its Water Drainage and Erosion/ Sedimentation Control Ordinance #9763 in 1983. It is complete in its approach to flood control within the urban areas. The ordinance can be updated as necessary and could be made more restrictive. No need for additional updating is anticipated, so the alternative does not need further consideration.

Shoreline Management Program. Development on or nearby the shorelines can have an effect on the amount of damages incurred and can modify the flood characteristics. The state Shorelines Management Act (SMA, Chapter 10.58 RCW) mandated local development of shoreline master programs to manage and regulate uses of the shorelines. Skagit County adopted its Shoreline Management Master Program in 1976 in compliance with the Act. As described in Chapter 4, the program includes protection and use of the river for flood control work. No additional consideration of this option is necessary, as the County is in compliance with the regulations.

Risk Management

All flood control management can be seen as risk management, but for the purposes of this plan, risk management is taken to address personal risks. An individual's ability to take responsibility for the risks associated with the flood prone area can be enhanced through several measures. The measures include flood proofing, public information programs, and other preparedness measures that can abate flood damages to the residents of the flood plain.

Flood Proofing. Buildings within the flood plain can be protected from flood damage. Buildings can be elevated and windows and doors can be fitted with water tight seals. Water resistant building materials can be used, and utilities such as sewers and electricity can be protected from damage.

Skagit County has addressed flood proofing in the Flood Damage Prevention Ordinance. Flood proofing is required by FEMA for flood insurance purposes, and the ordinance upholds all of the FEMA requirements. The ordinance acts as a type of building code for structures within the flood plain. As flood proofing is required, no additional analysis of this alternative is necessary.

Public Information Programs. An informed community can better respond to flooding problems and can better manage the personal risks that they will bear. An education program could focus on general flood plain awareness, and preparatory actions they might need to take in the case of a flood emergency. Giving seminars to school children or civic groups about the flood plain and distributing information on emergency services and procedures are some of the public information options available. Public interest is high when a serious event has recently occurred. Interest and concern diminish very rapidly.

Typically, a general education program would be designed and implemented by a local emergency services agency. In general, these general programs have limited effect when no danger is perceived by residents. If desired, the County could cooperate with a local agency in sponsoring a general education program, but further consideration of such as a flood control option is not warranted.

Specialized public information programs have also been used by the County to abate flood damages. Public officials have met with citizens of localized areas which experience frequent flooding. The citizens were provided information about flood danger and possible mitigating measures. Certain communities have taken the information and have developed plans to warn each other about an impending flood and help each other with preparedness plans. A localized public information program can be effective when it is timely and the need exists. The County may continue to pursue this flood control option.

Enhanced Flood Plain Management

A coordinated management effort applicable throughout the entire County can enhance equitability or integrity of flood control protection. Individual efforts at controlling flooding and drainage problems can be piece-meal and have damaging downstream effects. A consistent, systematic process for flood control measures that is designed to best serve public and private concerns, as well as maintaining hydraulic control over the flood control being accomplished should be part of a flood plain management effort.

The County has in effect ordinances and permitting processes to manage flood plain activities. Yet the control of the facilities has been delegated to locality of the problems through

diking and drainage districts. The diking and drainage districts have the responsibility for maintaining the diking and drainage systems, and funding within their boundaries. The revised code of Washington Chapters 85 and 86 regulate the actions of the districts. Permit application and review procedures are required to prevent piece-meal flood control projects. The County has a good relationship with the districts and will encourage the development of additional districts as necessary. Formalized coordination and cooperation between the districts could be beneficial also.

Emergency Response Measures

In the event of an actual flood, measures can be taken to reduce risks and public and private losses. As soon as the flood warning is announced, preparedness plans can be implemented, sand bagging crews can be stationed, and evacuations could take place in specified locations.

Skagit County emergency services is responsible for the development and implementation of the flood emergency plan. Preparedness plans are distributed to all residents and businesses as well as emergency response agencies. The agencies are contacted in the case of an impending flood and required actions are taken to implement the plans.

The County trains sand bagging crews through the local fire departments and also has cooperation from military in combatting rising river heights. The city of Mt. Vernon has not experienced damage in recent years due to the efforts of these flood fighting teams.

Evacuations in some areas are necessary during the floods. Currently, evacuation of the upper valley floodplains begins at the 10-year flood frequency, and the lower floodplain areas where a levee failure is imminent at a 20-year flood frequency or greater. Permanent evacuations of areas that are flooded frequently may be the only option available if protection by other measures is economically unfeasible. The costs incurred for this type of project include moving damageable property, paying for new sites and demolishing old ones, and reimbursing losses.

Emergency preparedness and response are necessary actions to deal with flooding. Skagit County implements and successfully carries out emergency services at high water periods. These measures are not viewed as flood control options by the County. It is unwise to depend upon emergency action teams for protection given the types of things that can go wrong. FEMA does not recognize flood fighting as an adequate measure and will not reduce flood insurance rates for areas that are protected by flood fighting. This plan will not consider emergency response measures as a flood control option.

Summary of Non-Structural Alternatives

Skagit County, throughout its history, has had to mitigate flood damages and has implemented all of the possible policy and non-structural alternative measures that can control flood damages. As necessary, the policies and procedures should be updated. The County could engage in a public information program in coordination with a local agency to enhance awareness. Otherwise, the only non-structural alternative to consider further is updated flood plain management, formation of new drainage and diking districts, localized public information programs, and permanent evacuations. Floodway acquisition will also be investigated as a means of flood storage.

CHAPTER 6

POTENTIAL IMPACTS OF FLOOD CONTROL MANAGEMENT OPTIONS

Flood control management is necessary to protect the lives, property and economy of Skagit County. Yet flood control work has potential impacts on the environment. Natural resources and in-stream uses are important to preserve, but can become endangered through flood control work if mitigation measures are not taken. This chapter discusses the possible impacts on the natural resources and in-stream usage of the flood control options presented in Chapter 5.

Table 6-1 lists the impacts on fish, wildlife, navigation, water quality, hydrology, existing recreation, and scenic, aesthetic and historic resources. The existing conditions are presented first, followed by a no action alternative. Although 'no action' is not an acceptable option, it is presented as a bench mark for comparison with other alternatives and its consideration is required by the State Environmental Policy Act (SEPA). Other options presented are those discussed in Chapter 5 which are considered viable for the county today.

The alternatives discussed are not necessarily mutually exclusive. Some alternatives or aspects of alternatives could be combined. The purpose of describing these alternatives is to outline a menu of available courses of action.

Alternative	Fish resources	Wildlife resources	Scenic, aesthetic, and historic resources	Navigation	Water quality	Hydrology	Existing recreation
Existing conditions	Several anadromous fish species in both rivers; migration extends through 100-year flood plain boundary.	County has abundance of wildlife resources; within 100-year flood plain; deer, migrating water fowls and fur animals are most prevalent.	Indian shell mounds in delta areas and dry inland slough courses; early settlement historic features in LaConner; several outstanding natural areas.	Navigation in Skagit limited to shallow draft barges, small boats and logs; only South Fork Channel is navigable.	Water quality is excellent.	Damage begins at flood stage of 65,400 cfs at Mt. Vernon; serious flooding occurs at 110,000 cfs and greater. At 82,000 cfs Hamilton begins to flood.	Several boat landing facilities along rivers; parks, public fishing and hunting; recreation areas.
No action alternative	Existing trends continue; major floods carry extensive silt, gravels and velocities which cover or destroy spawning beds.	Existing trends continue; some wildlife destroyed during major floods.	Unmitigated damage unaesthetic. Takes years to recover. Threat of damage to historic structures.	Excessive siltation possible; channel changes inhibit navigation.	Degraded during floods.	Frequency of annual flooding could increase due to development.	No recreation at flood stage; existing trends continue.
<u>Structural Alternatives</u>							
Maintaining existing flood control works	Protects resources through maintaining established flood control works--possible impact during repairs.	No change from existing conditions.	Maintaining works preserves aesthetics of area.	Maintaining ensures existing conditions continue.	Temporary degradation during repairs and maintenance--existing trends continue.	Possible alteration during repairs.	Continued protection of existing recreational areas; possible disruption during repair period.
Enhancing existing flood control works	Continues existing protection of resource--possible impact during construction.	Little change from existing conditions.	Enhancement could include improving aesthetics of existing works.	No change from existing conditions.	Temporary degradation during construction--existing trends continue.	Depends on project; purpose is to improve flood conveying capacity.	Existing conditions continue.
Levees and dikes	Potential habitat reductions due to vegetation clearing, increased development of flood plain resulting in secondary impacts; temporary effect during construction; increased velocity and erosion causing harmful sedimentation.	Potential impact to bald eagles due to impact on fisheries; disruption of wetlands and salt water marshes.	Some historic and archaeology sites may be affected; will protect other historic sites. Aesthetics will change.	No impact.	Temporary degradation during construction; impacts reduced during flood.	Existing hydrology altered. Water on other side trapped and needs to be pumped or channeled in side ditch. Flood damage frequency reduced. Channel capacity reduction could increase velocities and erosion potential.	River access could be affected--possible increase of opportunities on flood-prone lands.
Coastal Control:							
Tide or flood gates	Negative impact on high tides--inhibits fish migration.	Only as it impacts fisheries.	Aesthetics change.	Navigation not possible due to stream obstruction.	Temporary degradation during construction--limits saltwater intrusion.	Flow of water changed during high tide periods.	Impacts only as affects navigation.
Bulkheads, floodwalls and dikes	Impacts on marine habitats during construction.	Disruption of salt water marshes.	Protects historic sites. Aesthetics change.	Enhances the passage through the Swinomish Channel.	No impact.	Wave actions dampened; limits saltwater flows.	Protects, enhances navigational channels, possible hindrance to boat launching facilities.
Flood Storage:							
Holding ponds	Enhanced due to control on siltation and aggradation; possible migration problems if made impassable.	No impact.	Improved aesthetics after flood due to reduction of overbank flows.	Not applicable.	Improves water quality by reducing silt and aggradation load.	Peak flows reduced; duration of flows increased.	No impact.
Detention structures	Enhanced due to control on siltation and aggradation; possible migration problems if made impassable.	No impact.	Aesthetics change.	No navigation due to obstruction.	Improves water quality by reducing silt and aggradation load.	Peak flows reduced; duration of flows increased.	No impact.
Floodway acquisition storage	Existing conditions continue.	Existing conditions continue; no impact to wetlands.	Aesthetics improved; more natural setting.	No impact.	Existing conditions continue.	Existing conditions continue; peak flows remain reduced.	Existing conditions continue; possible location for future recreation site.

Table 6-1 Impacts of Alternative Flood Control Options

Alternative	Fish resources	Wildlife resources	Scenic, aesthetic, and historic resources	Navigation	Water quality	Hydrology	Existing recreation
Structural Alternatives, continued							
Channel maintenance and modification:							
Bank stabilization: Rip rap Vegetal cover Gabions Revetments	Habitat reduction if vegetative clearing; rip rap better than gabions.	No impact.	Potential effect on aesthetics. If erosion is prevented, aesthetics improved.	No impact.	Reduces sedimentation and improves water quality.	Bank hardening may divert velocities to downstream	No impact.
Debris removal	Habitat reduction due to shade removal and food source; could improve migration.	Could affect home environment of beavers.	Improved aesthetics.	Navigation improved.	Temporary degradation during removal.	Removal enhances flow of water--removes restrictions that cause increased backwater.	Enhances access to water areas.
Removal of restrictions	Depends on restriction; could improve migration.	No impact.	Depends on restriction; could improve aesthetics.	Navigation could be improved.	Temporary degradation during removal.	Enhanced passage of flow; backwater reduced.	Depends on type of restriction-no impact probable.
Flow diversion	Resident fishery could be installed in channel.	Could affect migratory waterfowl.	Some resources could be affected; depends on size of project.	No impact if control structure does not obstruct river.	No impact.	Increased storage and conveyance will reduce peak flows.	Depends on location--increased opportunities along diversion.
Enlargement or dredging	Channel capacity increase would enhance habitat reduced due to channel modifications; temporary effect when dredging.	No impact.	Little or no impact.	Navigation enhanced.	Temporary degradation during removal.	Increased capacity reduces velocities and erosion potential.	No impact.
Control of contributing area:							
Increase infiltration	Reduced peak flows and velocities protects environment.	Benefit in increased vegetative cover & groundwater recharge for wetlands.	Improved aesthetics.	No impact.	Reduces sedimentation and improves water quality.	Peak flows and volumes reduced.	No impact.
Conveyance	Improved fish migration through culverts and ditches.	No impact.	Could improve aesthetics.	No impact.	Conveyance of water normally stored could degrade water quality.	Quantity of flow in river increased; flow patterns altered slightly.	No impact.
Non-Structural Alternatives							
Updated and improved flood plain management	Existing conditions continue or enhanced.	Existing conditions continue or enhanced.	Existing conditions continue or enhanced.	Possible improvement.	Possible improvement.	Coordinated effort should improve hydraulic and control contributing flows.	Existing conditions continue or improve.
Formation of new diking and drainage districts	Potential for improvement.	Potential for improvement.	Potential for improvement.	Possible improvements.	Possible improvement.	Probable improvement due to increased control.	Possible improvement.
Localized public information program	Potential for improvement.	No impact.	Possible improvement.	No impact.	Possible improvement.	No impact.	No impact.
Permanent evacuation	No impact.	Wildlife may reoccupy area.	Possible improvement.	No impact.	Existing conditions continue.	Removal of building reduces obstructions and backwater.	Possible location for recreation site.

Table 6-1 Impacts of Alternative Flood Control Options, continued

CHAPTER 7

EVALUATION OF FLOODING PROBLEMS AND CONTROL ACTIONS

Skagit County has many and varied flooding issues and has numerous options for flood control, each with its unique benefits, impacts, and costs. These alternatives must be evaluated for their appropriateness in solving the flooding problems in the County. Once solutions are determined for each problem area, they must be prioritized in order of severity and importance to the County overall. This chapter provides alternative analyses for each problem area and develops a list of preferred alternatives for the County to pursue.

ALTERNATIVE ANALYSIS

The evaluation of flood control problems and alternatives is best approached over a reach of the watershed, rather than by specific problem location, due to the widespread and varied nature of the problems. Separate areas of the county have similar problems and needs, and specific control measures are appropriate for each different area. The floodplain can be divided into five areas: leveed areas (lower valleys), coastal areas, urban/rural areas, upper Skagit/Samish valleys, and feeder streams. A definition of each area, a description of the problems, and needs of the general area are presented first, followed by an alternative analysis in Tables 7-1 through 7-5, and is concluded with a list of preferred alternatives for each area.

Leveed Areas

This area encompasses land immediately adjacent to and including the existing lower Skagit and Samish Valley levees, and includes sloughs and other ditches that have levees near them. Areas farther from the levees are addressed under the urban/rural alternative.

General Problems. Flood problems within the leveed areas generally relate to maintaining the levees and routing water from one side of the levee to the other. The channelized stream at flood stage has a higher velocity than the non-leveed river would have, and the erosion capabilities are much higher. Thus, the levees are exposed to these high eroding velocities, and must be

continually maintained. Maintenance includes bank stabilization, with riprap or vegetation, and repairing sections, which have sloughed and need replacement.

Drainage that is prevented from flowing naturally into the river due to the levees must be conveyed properly. Existing drainage pumps must be maintained, replaced as necessary, and additional pumps and/or channels and conduits must be installed to prevent and relieve flooding behind the levees.

Sand boiling can also be a problem. When the hydraulic head of the river is above the surrounding ground elevation during flood stage, areas of sand material can quicken and boil, allowing flow to pass under the levee to the other side. These sand boils must also be detected and remedied to prevent major levee failure. Sand boiling is most frequent at the Avon Bend.

Another issue during flood stage in the floodplain is emergency access. If a major levee failure were to occur, entire areas would be inundated, including roads which emergency crews need to use to administer aid and to repair the damage. Existing levees can be enhanced through widening and raising, to allow vehicles to be able to drive along the top of them.

Specific Problems. Some specific problems associated with levees, as described in Chapter 2, include: area No. 6--maintenance of big ditch underpass under Fisher Creek; and area No. 7--repair sloughed levee on the left bank of North Fork Skagit River. Continuing flood control projects also include all the existing levees, pumps, and riprapped areas adjacent to the leveed areas.

Assumptions Used for Evaluation Purposes. Because the area is defined as existing leveed areas and related problems, several of the alternative solutions do not apply. Coastal control and control of contributing area fall under other area categories and are covered in another section. Under the discussion of new structural alternatives, additional levees is listed. Since most of the area in the Lower Skagit/Samish area is leveed already, this alternative will not be applicable in most cases. Flood storage is not practical in the lower reaches of the river system, as there would be too much volume flow to control. The area is completely divided into drainage and diking districts, so no new ones need to be formed. The levees provide sufficient protection so that permanent evacuation is neither necessary or politically possible.

Channel maintenance is a good control measure, but a distinction must be made between channel maintenance and existing flood control works maintenance. Within this area it will be assumed that levee maintenance includes bank stabilization and removal of debris and related constrictions. It also includes

Table 7-1

Skagit Comprehensive Flood Control Management Plan Evaluation of Alternatives

Leveed Areas

ALTERNATIVE	OBJECTIVE: reduce threat	reduce damage	protect economy	provide effective emergency response	maintain existing flood control	enhance existing flood control	maintain in-stream uses and resources	maintain safe transportation	equitable, county-wide protection	maintain local control	efficient use of public dollars	overall effectiveness
Maintain existing flood control works	✓	✓	✓	–	+	•	✓	✓	✓	✓ +	+	✓ +
Enhance existing flood control works	✓ +	✓	✓ +	✓	+	+	✓	✓ +	•	✓	+	✓ +
New Structural Alternatives:												
Levees	✓	✓	✓	✓	•	•	~	✓	• –	✓	* [a]	✓ –
Flood storage	~	✓	• –	~	•	•	✓	✓	–	✓	–	–
Channel Maintenance:												
Flow diversion	✓	✓	~ [b]	✓	✓ •	•	✓ ~	–	• –	–	✓	•
Enlargement/ dredging	•	•	•	•	✓ •	•	✓ •	•	•	✓ •	* [a]	•
New bank stabilization	✓	✓	✓	•	•	•	✓ •	✓	✓	✓ •	✓	✓
Non-Structural Alternatives:												
Enhanced flood plain management.	•	✓ •	✓	✓ •	•	•	✓ •	•	✓	+	+	✓
Specific public information programs	•	•	✓	✓ •	•	•	✓	✓ •	✓	+ +	+	✓

Legend:
- + benefit
- ✓ positive impact
- • neutral or non applicable
- – negative impact
- * impact depends on project
- ~ mixed impacts

a. cost depends on size of project, amount of protection

b. flow diversion could have negative impacts on economy through routed area.

Table 7-2

Skagit Comprehensive Flood Control Management Plan
Evaluation of Alternatives

Coastal Area

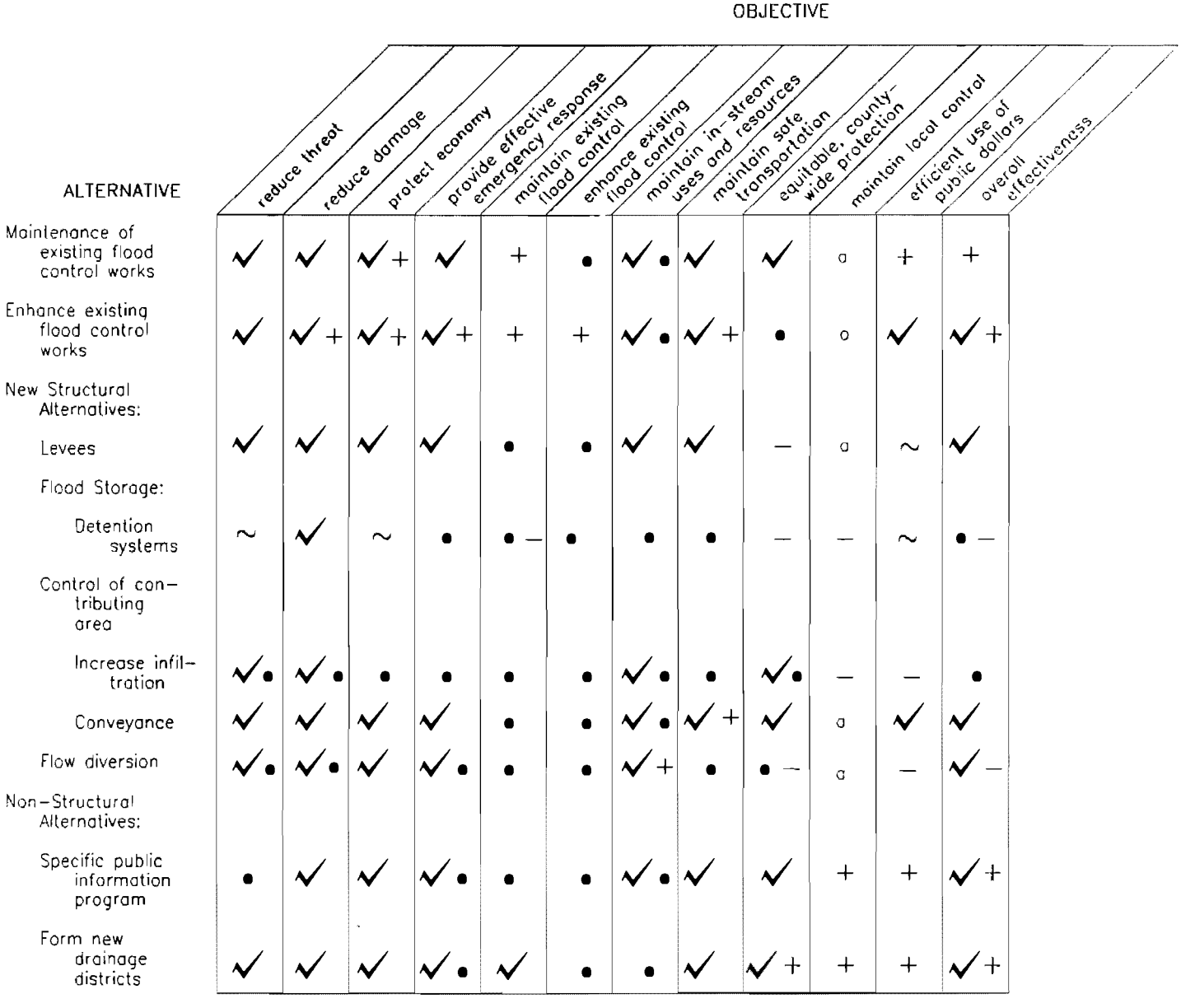
ALTERNATIVE	OBJECTIVE: reduce threat	reduce damage	protect economy	provide effective emergency response	maintain existing flood control	enhance existing flood control	maintain in-stream uses and resources	maintain safe transportation	equitable, county-wide protection	maintain local control	efficient use of public dollars	overall effectiveness
Maintain Existing flood control works	✓	✓	✓	• –	+	•	✓	✓	✓+	✓	+	✓+
Enhance Existing flood control works	✓+	✓	✓	✓	+	+	✓	✓	• –	✓	+	✓+
New Structural Alternatives:												
Dikes	✓	✓	✓	✓	•	•	~	*	–	✓	*	✓
Tidegates	✓	✓	✓	✓	•	•	–	•	–	✓	✓	✓
Non-Structural: Alternatives:												
Specific public education	•	✓	•	✓	•	•	✓	•	✓	+	+	✓

Legend:
+ benefit
✓ positive impact
• neutral or non applicable
– negative impact
* impact depends on project
~ mixed impacts

Table 7-3

Skagit Comprehensive Flood Control Management Plan
Evaluation of Alternatives

Urban/Rural Areas



Legend:
- \+ benefit
- ✓ positive impact
- ● neutral or non applicable
- – negative impact
- * impact depends on project
- ~ mixed impacts

a. There is local control only if the area is within a drainage/diking district.

Table 7–4

Skagit comprehensive Flood Control Management Plan Evaluation of Alternatives

Upper Skagit/Samish Valleys

ALTERNATIVE	OBJECTIVE: reduce threat	reduce damage	protect economy	provide effective emergency response	maintain existing flood control	enhance existing flood control	maintain in-stream uses and resources	maintain safe transportation	equitable, county-wide protection	maintain local control [c]	efficient use of public dollars	overall effectiveness
Maintain existing flood control works	✓	✓	✓	✓•	+	•	✓	✓	✓	c	+	++
Enhance/Improve existing flood control works	✓	✓	✓	✓	+	+	✓	✓	•✓	c	+	✓+
New Structural Alternatives:												
Levees [b]	~	~	~	•	•	•	~	✓	–	–	*	~
Flood Storage:												
Floodway acquisition	✓•	✓	•	•	•	•	✓	•	•–	–	~	~
Dam/reservoir [a]	+	+	+	+	•	•	=	✓	+	–	*	–
Channel maintenance & modification:												
Bank stabilization	✓+	✓+	✓	✓•	•	•	✓	✓+	✓•	–	✓+	✓+
Debris removal	✓	✓	✓	•	•	•	✓	✓	✓•	–	✓	✓
Removal of restrictions	✓	✓	✓•	✓•	•	•	✓	✓+	–	–	*	✓
Flow diversion	✓•	✓•	•–	•–	•	•	✓+	•	–	–	~	•–
Dredging	✓+	~	✓	•	•	•	✓•	✓•	✓	–	✓	✓
Non-Structural Alternatives:												
Evacuation	✓	✓+	•	+	•	•	✓	•–	=	–	✓	–
Specific public information program	•	✓	•	✓	•	•	✓	•	✓	+	++	✓
New diking and drainage districts	•	•	✓	•	•	•	✓	•	✓	++	+	✓

Legend:
- \+ benefit
- ✓ positive impact
- • neutral or non applicable
- – negative impact
- * impact depends on project
- ~ mixed impacts

a. Illegal due to Wild and Scenic Rivers Act
b. Additional levees in the Upper Skagit Valley would help in some areas, and would worsen flooding problems in other areas.
c. Local control is maintained if area is within drainage/diking district.

Table 7-5

Skagit Comprehensive Flood Control Management Plan
Evaluation of Alternatives

Feeder Streams

ALTERNATIVE	OBJECTIVE: reduce threat	reduce damage	protect economy	provide effective emergency response	maintain existing flood control	enhance existing flood control	maintain in-stream uses and resources	maintain safe transportation	equitable, county-wide protection	maintain local control	efficient use of public dollars	overall effectiveness
Maintain existing flood control works	✓	✓	✓	✓•	+	•	✓	✓	✓	a	+	++
Enhance existing flood control works	✓	✓	✓	✓	+	+	✓	✓		a	✓	+
New Structural Alternatives:												
Levees	✓	✓	✓	✓	•	•	✓	✓	✓ −	a	✓	✓
Flood storage:												
Holding ponds	✓	✓	✓+	✓ +	✓	•	✓	✓	✓•	a	✓ −	✓
Detention storage	✓	✓	✓	✓ +	✓	•	✓	✓	✓ +	a	✓ −	✓
Floodway acquisition	✓	•	•	✓	•	•	✓	• −	• −	• −	✓ +	✓
Channel maintenance:												
Bank stabilization	✓	✓	✓	✓•	•	•	✓	✓+	✓	−	✓ +	✓
Debris removal	✓	✓	✓•	•	•	•	✓	✓	✓•	−	✓	✓
Flow diversion	✓•	✓•	• −	• −	•	•	✓ +	•	−	a	✓ −	•
Dredging	✓•	✓	✓	✓•	✓	•	✓	•	✓•	−	✓	✓
Non-Structural Alternatives:												
Evacuation	✓	✓ +	•	+	•	•	✓	•	=	−	✓	−
Specific public information programs	•	✓	•	✓	•	•	✓	•	✓	+	++	✓
New drainage/ diking districts	•	•	✓	✓•	•	•	✓	•	✓	++	+	✓

Legend:
- \+ benefit
- ✓ positive impact
- • neutral or non applicable
- − negative impact
- * impact depends on project
- ~ mixed impacts

a. local control is maintained only where there are existing drainage districts or sub-flood control zones.

maintenance of pumping facilities which route contributing flow from other areas, and riprap which has been placed on the levee banks for stabilization. Additional channel maintenance would consist of enlargement and/or dredging and flow diversion.

Enhancement of existing flood control work would include raising the heights to increase flood protection, and to widen the levees to provide for emergency vehicle movement. Increasing pump capacity and increasing integrity of riprapped areas would also be included.

Preferred Alternatives. Given the definition of the Lower Skagit/Samish leveed areas, the preferred solutions as determined from Table 7-1 are maintaining and enhancing existing flood control works. These solutions best meet the County's goals. If additional work is required, additional levees and riprap bank stabilization seem to be the best solution alternatives. Flow diversion and dredging are neutral at best, and their effectiveness would depend on the type of problem and amount of increased protection they would offer. Flood storage is probably not a feasible type of flood control option in the lower reaches of the Skagit.

The preferred solution for specific problem areas 6 and 7 is maintenance and repair of the existing flood control works.

Coastal Areas

Coastal areas are defined as those areas that have contact with salt water, are adjacent to saltwater dikes, or are otherwise affected by tidal influences. The entire westerly boundary of the county, plus areas extending up the mouths of the sloughs and rivers that are affected by tides are included.

General Problems. General problems in the coastal area consist primarily of maintaining, repairing, and enhancing the existing dike network. Nearly the entire westerly boundary of the county is diked, and sections are in various states of disrepair. Dikes have the same problems as levees, in that during high tides, storm drainage tends to pond behind them and the water must be pumped out if flooding problems occur. Tide gates must also be maintained to ensure proper working and flow passage.

Most of the dikes in the county have been designed to accommodate book tides only, and overtop if high tides are accompanied by high winds and low barometric pressure. Specific problem areas cited include area No. 8--repair of the Padilla dike, and general maintenance of existing dikes, pumping stations, and tide gates.

Assumptions Used for Evaluation Purposes. Coastal areas require both coastal control measures and non-structural measures to mitigate flood damages. Other structural control (levees, flood storage, channel modifications, and control of contributing area) either do not apply to coastal areas or will be covered in another section. Maintenance of existing facilities includes stabilizing and maintaining all existing dikes, pumping stations, and tide gate structures. Any new diking or flood gates that would be installed would include necessary pumps, flap gates, and other conduits necessary to pass storm water during non-coastal periods.

Preferred Alternatives. Again, maintenance and increasing integrity of existing measures are the most goal-achieving methods of mitigating flood damages along the coast, according to Table 7-2. Depending on the problem and potential flood damage in specific areas, additional dikes, pumps, and flood gates could be used with generally equal preference. The solution in specified problem area of the Padilla dike should be repair and replacement of the dike.

Urban and Rural Areas

This area is defined as the area within the floodplain that is not included in one of the other areas. Generally, this includes agricultural and urban lands removed from the adjacent river, creek, or levee, but still within the floodplain area.

General problems within this area consist of localized drainage and flooding problems. Poorly maintained, broken, and misaligned pipes and culverts create ponding and localized flooding during heavy rains. Increases in development will magnify runoff peaks and volumes, and additional flows will need to be conveyed efficiently to the river to prevent localized flooding. These areas are also generally protected from the main river by a levee or embankment. In the case of a major flood, with levees overtopped or failed, excess flood waters would need to be efficiently removed.

An existing problem specified within this area is Gages Slough (Area 12) which can be improved as a drainage and floodway. Conveyance problems would generally occur within this urban/rural area.

Assumptions Used for Evaluation Purposes. The urban and rural areas are defined to be those areas removed from the main river or creek, but still within the floodplain. Therefore, maintenance or attention to the main stream channel will not fall under this category.

Existing flood control within the urban/rural areas would consist of all existing drainage, conveyance, and detention systems, including channels, conduits, culverts, outlet and inlet structures, and any drainage pumps and detention storage. Maintenance of these items would include cleaning and repairing broken and misaligned pipes and culverts, removing debris, clearing weeds, and removing restrictions.

Any new construction of conveyance systems would include channel construction, installation of conduits, culverts, inlet and outlet structures, and necessary drainage pumps.

The responsibility of maintaining conveyance systems belongs to the owner of the system, be it a city, town, private citizens, or a drainage district. Additional drainage districts could be formed to take responsibility of this. Specific public information programs would be addressed to some of these groups or agencies.

Preferred Alternatives. Maintaining the existing conveyance system is the best method of meeting the County's goals, as noted in Table 7-3. The formation of new drainage districts where none currently exist is essential for financing and overseeing maintenance and capital improvement projects. As most projects will be instituted between various groups (cities, individuals, and drainage districts) specialized public information programs that would enhance coordination and inform of perceived problems and alternative solutions is also a good option. Other methods, such as adding to the conveyance systems or installing berms and levees could be used where necessary. Detention systems and increased infiltration do help control runoff rates and volumes, but contribute little during major storm events when flooding occurs, and are not highly recommended flood control options. Flow diversion would be a specialized option applicable only to certain situations, and would need to be carefully evaluated in the pre-engineering planning stage. For problem area No. 12 (Gages Slough), enhancing the natural drainageway would be the preferred alternative

Upper Skagit/Samish Valleys

This area is defined as those along the main river which are within the floodplain and are not adequately protected by levees. This would include Nookachamps Creek area and the entire Skagit floodplain to the east of Burlington and unleveed areas of the Samish River. Floodplains of tributaries to those rivers will be discussed in the next section.

General Problems. This area experiences major flooding damage, as it is in the floodway and is generally unprotected. Debris and point bar accumulations due to normal river processes could cause major channel change during high velocity flows in a

flood period. Erosion on the outer bank during high flow periods endangers existing structures and can cause a major channel change.

Many areas within the Upper Skagit Valley are listed as problem areas in Chapter 2. Potential areas of channel change due to erosion and point bar accumulations are in problem area Nos. 2, 3, 4, and 11 near Gilligan's Creek, Lyman, Van Horn, and Burlington. Erosion is encroaching on existing structures in area No. 5 (Cape Horn Road) and area No. 10 (Highway 9 bridge at Sedro Woolley). Cockreham Island (area No. 13), Hamilton (area No. 14), and the Nookachamps Creek area are completely inundated during a major flood event.

Assumptions Used for Evaluation Purposes. As the feeder streams are addressed in the next section, the alternative evaluation applies only to the areas within the main floodplain of the upper river valleys. Holding ponds and storage are not appropriate in this area, as flows are too great to be contained. Dredging would be used to remove point bar accumulations, debris accumulations would refer to logs and other material that might be impeding flow.

Existing flood control works include riprap along some bank segments and the Cockreham Island levee.

Preferred Alternatives. Table 7-4 shows that many alternatives are available in the upper valley areas, as little flood protection currently exists in this area. Maintenance of the existing bank stabilization and installing new bank stabilization would be most effective at protecting the county from further flood damage and would meet the County's goals. Dredging and debris removal are also good alternatives, and could be considered equal with bank stabilization if they are considered to be maintenance alternatives within the river. Restriction removal would be effective, although there are no known restrictions in the area. Although public information programs and new districts within these areas may not reduce threat and damage, both are non-structural and offer some local control of protection to the area.

Floodway acquisition and additional levees are less desirable alternatives. New levees, especially near Burlington, could offer protection to the north areas, but would cause an increase in flood depths in the Nookachamps Creek area. Flow velocities and volumes farther upstream are such that a new levee would need extra reinforcement and height to withstand flood conditions, and would not be allowed with the proposed state floodplain regulations. Floodway acquisition would maintain natural flood storage in the upper valley for the benefit of the lower river areas at the expense of the existing property owners.

Permanent evacuation of frequently inundated areas would prevent further damage, but is highly undesirable from the point of view of persons who want to live within those areas.

An alternative that could solve flooding problems in both the upper and lower valleys would be the construction of a dam or reservoir on the Sauk or Suiattle Rivers. This is not possible, though, due to its illegality based on the Wild and Scenic Rivers Act.

Flows diversion is not a viable option in the Upper Valley. The natural processes of the river change the course so much that the diversion may become obsolete and unusable in time as the river moves away from it, or the river may use it as a path of least resistance and may cause a major channel change.

Preferred alternatives for problem areas 2, 3, 4, and 11 would be dredging to remove point bar accumulations. Erosion areas 5 and 10 should receive bank stabilization. Areas 13 and 14 which are subject to complete inundation are candidates for specific education programs, if not floodway acquisition or permanent evacuation.

Feeder Streams

The feeder stream areas are defined as the designated floodplains not associated with the main river. These streams generally have steeper gradients through the mountainous areas which flatten out as the streams approach the main river.

General problems along the feeder streams include maintaining the stream within the channel area, controlling debris accumulations, preventing erosion, and channel maintenance. Logging practices in the upper basins have a large affect on the problems the stream causes where the stream gradient flattens out.

Specific problems noted in Chapter 2 with this area include area No. 1 (Friday Creek erosion), Area No. 9 (Hansen Creek deposits, and area No. 15 (Grandy Creek restriction and debris accumulations).

Assumptions Used for Evaluation Purposes. Maintenance of existing flood control structures in this area consists of riprap for bank stabilization and a holding pond. Logging practices have the greatest effect on the flooding of these areas, so the exact location of the problems is dependent on which areas are being logged.

Preferred Alternatives. Again, Table 7-5 shows that maintaining the existing holding ponds and rock riprap are the best methods for flood control in this area. Several other

methods can also be used to further reduce flood damages. Further stabilization of the banks and improvements of the holding ponds are also highly feasible solutions.

The remainder of the alternatives for this area meet the goals and objectives equally well, and a preferred use would depend entirely on the specifics of the problem and project. A holding pond is effective at reducing sediment and gravel load, and can be sized for detention storage to also regulate flow rates downstream. Bank stabilization should improve the chances of the stream staying within the appropriate channel. Dredging and debris removal should occur where accumulations have severely restricted the stream's channel. Shallow levees may be appropriate to keep a stream which has the tendency to veer from its course from traveling through a nearby field. Properties which experience frequent inundation could be acquired and developed into parks.

Although specific education programs and additional districts would not in themselves lessen the flood hazards, they are cost-effective options that meet the goal of having local control. Flow diversion could have mixed results; it could be a major benefit in some areas, while in others it would only move the problem or create new ones. Evacuation in this area is probably unnecessary and would be highly unpopular.

A holding pond/detention basin is a preferred alternative for problem area 9, Hansen Creek deposits. Grandy Creek restriction (Area 15) is candidate for debris removal, and additional study could be made of the feasibility of removing the restriction. Friday Creek (Area 1) should have some bank stabilization installed.

Summary

Table 7-6 lists the preferred alternative for each problem area within the County. For each problem area, the alternative which best met the County's goals is maintenance of existing flood control works. This alternative is eligible for Flood Control Assistance (FCAAP) funding, is equitable for the entire County, and maintains local control, as most existing projects are within a drainage or diking district. Although bank stabilization is included as maintenance of existing flood control works in several of the areas, it is restated in the preferred alternative table for completeness. Additional structural flood control work is necessary in the upper Skagit Valley and in the tributary feeder streams, as these areas experience frequent problems, and little has been done in the past to mitigate damage in these areas. Bank stabilization and debris removal are overall preferred alternatives for these areas, and are also eligible for FCAAP funding.

Other non-structural alternatives could be combined with the preferred alternatives to help meet the County goals better.

Additional drainage and diking districts can be formed in areas where none exist now, to give local control over the flood control works. Specific education to localized areas which are experiencing problems can only help residents become informed and participate in mitigating flood damages.

Table 7-6. Preferred Flood Control Alternatives by Area

Area	Alternative				
	Maintain existing flood control works	Bank stabilization	Debris removal	Holding pond	Specific education
Leveed area	✓	✓			
Coastal	✓	✓			
Urban/rural	✓	✓			
Upper Skagit/ Samish Valleys	✓	✓	✓		✓
Feeder streams	✓	✓	✓	✓	

CHAPTER 8

RECOMMENDED PLAN

Given the framework for flood control decisions and the various alternatives for flood control, preferred alternatives were developed for each area within the County, and for specific projects within these areas. The recommended flood control management plan prioritizes the current major flood control projects and lists associated impact reduction measures. Means for updating and implementing the plan are also presented.

General Prioritization

Goals and objectives stated previously in Chapter 4 were used to prioritize projects. Each project was evaluated based on how well it meets these goals (as stated in Chapter 4) of reducing flood threat, protecting the economy, reducing damage, etc. Appendix D contains the project ranking sheets used to determine project prioritization. The projects on the list were determined from a previous evaluation of alternatives (process described and outlined in Chapter 7). The final prioritized list reflects how each project achieves flood control objectives.

Although an assessment of the flood control situation has been made for the current situation, additional assessments will need to occur following a flood of any significance. Floods stress the existing facilities in sometimes unforeseen ways, and quite often produce a different set of priority actions than those of the pre-flood assessment.

Given the evaluation procedure described in the last chapter, the County can fairly evaluate and prioritize new flood control projects after a flooding situation. The prioritization can be broken down on a county-wide or geographic area basis. These geographic areas are shown in Figure 8-1. New areas of concern would be evaluated, scored, and placed on the post-flood prioritization list.

Tables 8-1 and 8-2 list the area- and County-wide prioritizations. They are general guidelines for developing a project list. A severe problem would produce a high priority score which may make it a different priority than the guidelines in these tables. Emergency, life-threatening situations would be addressed immediately and are not subject to this process.

Table 8-1. Prioritization by Area

Area	Priority[a]	Alternative
Leveed area	1	Maintain existing flood control works
	2	Enhance existing flood control works.
	3	Specific education.
Coastal area	1	Maintain existing flood control works.
	2	Enhance existing flood control works.
	3	Specific education.
Urban/rural areas	1	Maintain existing flood control works.
	2	Enhance existing flood control works.
	3	Improve drainageways.
	4	Specific education.
	5	Form additional districts.
Upper Skagit/ Samish Valleys	1	Maintain existing flood control works.
	2	Enhance existing flood control works.
	3	Stabilize banks.
	4	Remove point bar accumulations.
	5	Specific education.
	6	Form additional districts.
Feeder streams	1	Maintain existing flood control works.
	2	Enhance existing flood control works.
	3	Bank stabilization.
	4	Debris removal.
	5	Specific education.
	6	Holding ponds.
	7	Form additional districts.

[a]Lower numbers indicate higher priority.

Table 8-2. County-Wide Prioritization

Priority	Action
1	Maintain existing flood control works in feeder stream area.
2	Maintain existing flood control works in leveed area.
3	Enhance all existing flood control works County-wide.
4	Stabilize banks in Upper Skagit/Samish Valleys.
5	Remove point bar accumulations in Upper Skagit/Samish Valleys.
6	Maintain existing flood control works in urban/rural areas.
7	Improve drainageways in urban/rural areas.
8	Maintain existing flood control in Upper Skagit/Samish Valleys.
9	Stabilize banks along feeder streams.
10	Maintain existing flood control along the coast.
11	Remove debris from feeder streams.
12	Specific education programs County-wide.
13	Install holding ponds along feeder streams.
14	Form additional districts where necessary.

Dage Slough

An example of the revised post-flood prioritization process is as follows. All emergency situations are stabilized and clean-up operations are made. After the flood, all existing flood control facilities (levees and dikes, pumps, riprap, drainage facilities,

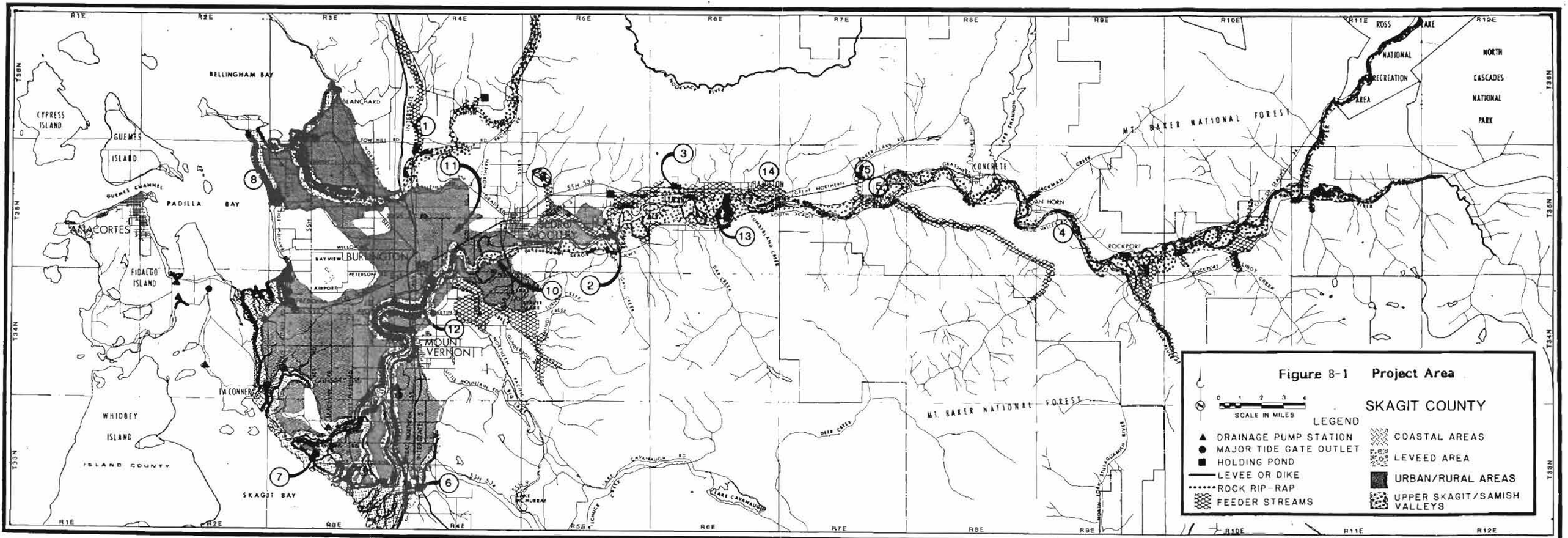


Figure 8-1 Project Area
SKAGIT COUNTY
SCALE IN MILES
0 1 2 3 4
LEGEND
DRAINAGE PUMP STATION
MAJOR TIDE GATE OUTLET
HOLDING POND
LEVEE OR DIKE
ROCK RIP-RAP
FEEDER STREAMS
COASTAL AREAS
LEVEED AREA
URBAN/RURAL AREAS
UPPER SKAGIT/SAMISH VALLEYS
BELLINGHAM BAY
CYPRESS ISLAND
GUEMES ISLAND
GUEMES CHANNEL
PADILLA BAY
ANACORTES
FIDALGO ISLAND
WHIDBEY ISLAND
ISLAND COUNTY
SKAGIT BAY
BLANCHARD
BURLINGTON
MOUNT VERNON
CONCRETE
ROCKPORT
MT. BAKER NATIONAL FOREST
ROSS LAKE NATIONAL RECREATION AREA
NORTH CASCADES NATIONAL PARK
LAKE CAVANAUGH
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
R9E
R10E
R11E
R12E
T36N
T35N
T34N
T33N

holding ponds) are inspected and assessed for damage and are given necessary routine maintenance. Both rivers are inspected over their entire length, noting areas of impending bank failure, debris and gravel accumulations, and potential channel changes. Other information, such as assessed damages and community input (reaction, distress) is also taken into consideration.

For an example, imagine that a flood occurs this fall with a 10-year frequency. As usual with a 10-year flood, the upper valley will be flooding, but the levees will have protected the lower valley area, with an extensive flood fight at Mount Vernon. After assessment, the flood control engineer might note that the previous gravel accumulation near Van Horn had washed away during the flood. Also noted might be that the Avon Bend (Skagit levee at Avon) had suffered extensive abuse, requiring additional riprapping maintenance before the next flood. The Van Horn point bar accumulation would be removed from the project list. The preferred solution in the leveed area is maintenance of existing flood control works which would include riprapping an existing levee.

Levee maintenance is second priority County-wide, so it would probably have priority over the Padilla dike and Gages Slough projects. The project would be scored, along with a reassessment of the remaining projects, to obtain the new prioritized list.

Current Prioritized Project List

The following Table 8-3 lists the prioritized projects based on a current assessment of flood control facilities within the County. Project locations and numbers are also shown on Figure 8-1. Skagit County does not have full authority over these flood control projects. Many of the projects on this prioritized list are under the jurisdiction of diking and drainage districts, and others would need to have a district or zone created to maintain and oversee the proposed project. Although the list reflects the County's priorities, this may not be representative of the accumulative desires of all of the drainage and diking districts. Therefore, implementation of these projects is dependant upon local agency cooperation and coordination. Further planning and design will be accomplished for each project as time and budget constraints permit.

Table 8-3. Recommended Priority of Skagit County Flood Control Projects

Priority	Project	Area
1	No.7--North Fork sloughed levee Maintain existing flood control works by repairing the sloughed levee through the 1,000-foot section. Levee needs widening and reinforcing. The timing of the repair should be such that fish resources are minimally impacted and little chance of flooding exists during the repair period. The bank should also be stabilized at the same time to prevent further sloughing, along with possible widening to allow for emergency vehicle access to the area.	Leveed area
2	No. 8--Padilla Dike piling Maintain existing flood control work by repairing existing Padilla dike protective piling. Piling may be repaired, if possible, or replaced with additional piling or other suitable material in order to continue to dampen the strong wave action before it reaches the dike. Construction should be timed when wave action is low, marine habitats are at lower risk, and recreational activities will not be severely impacted.	Coastal area
3	No. 12--Gages Slough drainageway Improve natural drainageway through the old channel of the Skagit River which is now Gages Slough. Culverts and outlets need redesign and replacement, and the channel needs considerable work to effectively carry the flood waters away from the City of Burlington once a flood begins to recede. (A 25-year flood or greater would overtop Highway 20 and flood the entire Samish Valley.) Construction should be timed so as not to impact migrating waterfowl or put workers in danger in flood season.	Urban/rural area
4	No. 5--Cape Horn road bank stabilization Stabilize right bank of Skagit River along the long curve in the high gravel bank near Cape Horn Road. The stabilization may require piling and riprap reinforcement to protect the roadway and to armorize the high gravel bank. Construction should be timed for lower river flows and lower traffic volumes on Cape Horn Road. Efforts should be made to prevent excessive loss of vegetative habitat or structures that would divert velocities to other erosion-prone areas.	Upper Skagit Valley
5	No. 6--Big Ditch underpass repair Maintain existing flood control work through repairing the Big Ditch underpass through the Fisher Creek dike. Deteriorated structural pieces would need to be replaced and resealed to prevent water flowing under the structure and through the Fisher Creek dike. Construction should be timed to minimize risk and impacts.	Leveed area
6	No. 10--Highway 9 bridge bank stabilization Stabilize about 2,000 feet of eroded left bank of Skagit River downstream from Highway 9 bridge at Sedro Woolley. Riprap will be used to stabilize the bank. Construction will be timed to minimize impacts and construction hazard and will be designed to minimize diversion of velocities to other erosion-prone areas.	Upper Skagit Valley

Table 8-3. Recommended Priority of Skagit County Flood Control Projects, continued

Priority	Project	Area
7	No. 9--Hansen Creek holding pond Construct a holding and settling pond on Hansen Creek to control gravel and silt deposition. Coordination through Hansen Creek subflood control zone for maintenance and upkeep of the facility. Also, remove existing gravel and silt deposits that are flood hazards during a time when it will not affect fishery resources.	Feeder streams
8	No. 1--Friday Creek bank stabilization Stabilize a high, unstable eroded bank on the 90° turn on Friday Creek to prevent landslide and possible damming of the stream. Time construction so as to minimize impact to fisheries.	Feeder streams
9	No. 15--Grady Creek debris removal Remove buildup of gravel and silt and other debris at railroad bridge crossing Grady Creek just north of Highway 20. Assess area to determine whether the restriction can be lessened. Remove gravel at a time when water quality would impact fish resources and in enough time before fish runs to allow some stabilization of the area.	Feeder streams
	Other Priority Areas	
10	No. 14--Specific education program for Hamilton	Upper Skagit Valley
11	No. 11--Burlington point bar accumulation removal	Upper Skagit Valley
12	No. 3--Remove point bar accumulations near Lyman	Upper Skagit Valley
13	No. 13--Specific education program for Cockreham Island	Upper Skagit Valley
14	No. 4--Remove point bar accumulation near Van Horn	Upper Skagit Valley
15	No. 2--Remove point bar accumulation near Gilligans Creek	Upper Skagit Valley

Costs

Determination of financial impacts and funding alternatives is beyond the scope of this plan. However, some general costs for flood control maintenance actions have been compiled from recent projects. Specific project costs depend on the nature, size, and extent of the project and other variables, but Table 8-4 gives a general guideline as to the cost comparison between different actions. These costs include labor and equipment associated with the construction and do not include engineering, planning, or administration fees.

Table 8-4. Costs of Flood Control Maintenance Actions in Skagit County

Project	Cost, dollars
Gravel deposit cleanup, per lineal foot	10-25
Rock riprap repair, per lineal foot	10-50
Levee repair (riprap and lining), per lineal foot	70-100
Levee widening, per lineal foot	15-60
Pump station upgrade, per pump	20,000-60,000
Storm drain replacement, per lineal foot	25-100

Implementation Schedule

An implementation schedule for the prioritized projects is vital for timely flood control actions and effective use of public dollars. Successful implementation of this plan will depend on interagency coordination of planning, design, review, and final construction of the projects. The following implementation schedule outlines the steps necessary to be considered for FCAAP funding of projects. The FCAAP application process currently occurs on a two-year basis.

Milestone	Time
Release draft comprehensive flood control management plan	July 1988
Obtain comments and release final report	January 1989
WDOE approval of comprehensive plan	April 1989
Begin planning of priority projects	September 1988
Submit prioritized applications to WDOE	December 30, 1988
WDOE review of applications	April 1989
WDOE Public hearings	May 1989
Earliest date WDOE signs grant agreements	July 1989

APPENDIX A

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APPENDIX B

CHAPTER 7.16 SHORELINE STABILIZATION AND FLOOD PROTECTION

From: Skagit County Shoreline Management Master Program, December 1976

7.16 SHORELINE STABILIZATION AND FLOOD PROTECTION

1. POLICIES

A. General

(1) Streamway modification and marine diking programs should be coordinated and monitored to provide for more comprehensive planning of Skagit County's shorelines.

(2) Recognizing that streamway modifications may cause interference with normal river geo-hydraulic processes that may lead to erosion of other up and down river shorelines, then such modifications and stabilization measures should incorporate basic geo-hydraulic principles and be located, designed, coordinated, and maintained for homogeneous river reaches.

Such modifications and measures should be sited and designed by qualified professional personnel.

B. Design and Location

(1) All bank stabilization and flood protection measures should be constructed to comply with the design and location standards and guidelines of applicable agencies.

(2) Riprapping and other bank stabilization measures should be located, designed, and constructed primarily to prevent damage to agricultural land, public roads and bridges, existing homes and residential areas, or other structures or natural features whose preservation is in the public interest.

Such measures should not restrict the flow of the river or stream.

(3) Fish and Wildlife resources - Recognizing the value and interdependency of water bodies and associated wetlands as biologically productive habitats and recognizing the intent of the Shoreline Management Act (RCW 90.58.030(2) and WAC 173-22-030), shoreline stabilization and flood protection projects should be located landward of natural wetlands, marshes, and swamps of associated fresh and marine water bodies.

(4) Braided and meandering channels and associated shoreline areas should not be the locations for intensive land use developments such as those of an industrial, commercial, or residential nature.

(5) Substantial stream channel direction modification, realignment, and straightening should be discouraged as a means of shoreline and flood protection and for protection of roadway rights-of-way, navigational routes, and other construction or developmental projects.

C. Materials

(1) Shoreline stabilization and revetment material should consist of substantial rock and should meet the standards and guidelines of the Soil Conservation Service.

(2) Junk and solid waste should not be permitted for shoreline stabilization and revetment material. Concrete and concrete waste should not be used as stabilization and revetment material.

(3) Shoreline stabilization programs should utilize natural, perennial vegetation either as stabilization material alone or as complementary to other materials.

D. Natural Features

(1) Natural features such as snags, stumps or uprooted trees which support fish and other aquatic systems, and do not intrude on the navigational channel or reduce flow, and do not threaten agricultural land and existing structures and facilities should be allowed to remain.

E. Agricultural Practices

Recognizing the importance of vegetation as an aid to bank stabilization, agricultural operations should encourage grazing practices which enhance vegetation on and adjacent to streambanks. Cultivation to the water's edge should be avoided.

F. Alternatives

Shoreline stabilization programs should be encouraged to develop alternative methods of streamway modifications utilizing natural systems of stabilization and geo-hydraulic principles.

G. Impacts

(1) Recognizing that shorelines of recreation, wildlife, and aesthetic value are limited and irreplaceable resources, then shoreline stabilization and flood protection projects should consider their potential effects and impacts upon such resources.

(2) Recognizing that the related shoreline stabilization and flood protection activities of filling, grading, lagooning, and dredging may have a substantial impact upon the existing aquatic and biological systems, navigation, and river hydraulics by subsequent erosion and sedimentation, then these activities and their possible impacts should be recognized.

2. REGULATIONS

A. Shoreline Areas

(1) Urban

a. Shoreline stabilization and flood protection measures are permitted subject to the General Regulations.

b. Dams and impoundments are permitted as a conditional use.

(2) Rural Residential

a. Shoreline stabilization and flood protection measures are permitted subject to the General Regulations.

b. Channel modifications and dams and impoundments are a conditional use.

(3) Rural

a. Shoreline stabilization and flood protection measures are permitted subject to the General Regulations.

b. Channel modifications and dams and impoundments are a conditional use.

(4) Conservancy

a. Shoreline stabilization and flood protection measures are permitted subject to the General Regulations.

Natural character erosion control measures including current deflectors are to be utilized instead of bank revetments and rip rap whenever possible.

b. Dams and impoundments are permitted as a conditional use.

c. Channel direction modification, realignment, and straightening are permitted only as a conditional use.

(5) Natural

Shoreline stablization and flood protection measures, dams, impoundments, and channel modifications are prohibited except for vegetative bank stabilization measures.

(6) Aquatic

a. Shoreline stabilization and flood protection measures are permitted only as a conditional use.

b. Dams and impoundments are permitted as a conditional use only if compatible with the upland Shoreline Area regulations.

c. Current deflectors are permitted as a conditional use.

B. General

(1) Shoreline permit/statement of exemption - In order to assure that shoreline stabilization and flood protection measures are consistent with this program as required by RCW 90.58.140 (1), no work may commence without the responsible person or agency having obtained either a Shoreline Permit or Statement of Exemption from this department.

(2) Qualifications for approval - Shoreline stabilization and flood protection measures shall be allowed only when adequate evidence is presented that one of the following conditions exist:

a. Significant erosion of agricultural lands.

b. High water or erosion threatens public works and properties, including roads, bridges, railroads, and utility systems.

c. High water or significant erosion damages or threatens existing homes and residential areas.

d. High water or significant erosion damages or threatens to damage existing commercial and industrial uses and developments.

(3) Professional design - The County may require professional design of shoreline stabilization and flood protection works where such projects will cause interference with normal river geo-hydraulic

processes, leading to erosion of other up and down river shoreline properties or adverse effects to shoreline resources and uses.

(4) Channel modifications - River and stream channel direction modification, realignment, and straightening are not permitted unless for substantiated purposes connected with uses consistent with this program.

(5) Design and construction

a. Existing streambank vegetation shall be preserved to the maximum extent feasible during shoreline stabilization and flood protection work.

b. New or expanded dike, revetment, or riprap systems, cut-and-fill slopes, and backfilled areas shall be progressively planted with compatible, self-sustaining, and soil stabilizing vegetation.

c. All works shall allow for the passage of surface and ground waters.

d. All works shall be designed and constructed to meet the requirements and standards of the County Engineer, State Departments of Fisheries and/or Game, Corps of Engineers where applicable, and Soil Conservation Service.

(6) Materials

a. Materials for shoreline stabilization and flood protection works shall not consist of solid waste, junk or abandoned automobiles, asphalt or macadam, or any building demolition debris except that which is used for emergency purposes.

c. Techniques utilizing totally or in part vegetative bank stabilization procedures shall be preferred over structural means such as concrete revetments or extensive rip rap.

(7) Estuaries and wetlands - Any proposal to dike, drain, or fill tidelands, estuaries, salt marshes, and associated water bodies and wetlands shall provide a thorough evaluation of the natural productivity of the wetlands to be displaced and the proposed use.

(8) Dams and impoundments - Dams and impoundments shall be subject to applicable Shoreline Area regulations.

(9) Project information - The county shall require and utilize the following substantiating information during review of shoreline stabilization and flood protection proposals:

a. River channel hydraulics and floodway characteristics up and down stream from the project area shall be identified contingent upon the extent and nature of project work involved. Updated topography maps or phased (old and recent) aerial photography would be adequate.
b. Existing shoreline stabilization and flood protection works within the area stipulated above.
c. Physical, geological, and/or soil characteristics of the area.
d. Existing and proposed shoreline and water uses for the project area and area stipulated above.
e. Predicted impact upon area shore and hydraulic processes, adjacent properties, and shoreline and water uses.

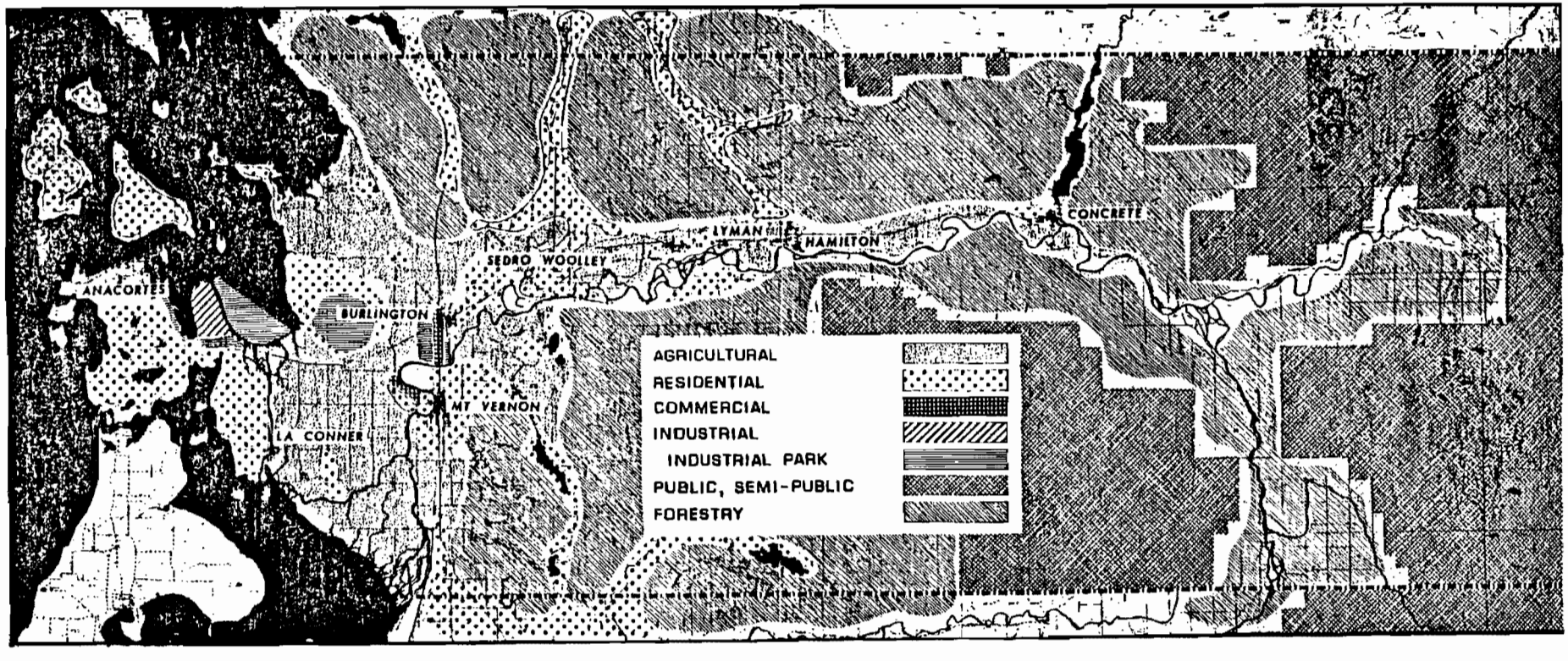

Figure C-1 Skagit County Current Land Use

APPENDIX D

PRIORITIZATION WORKSHEET

Prioritization Worksheet - Ranking Sheet

Skagit County

Projects	Project Rankings: Objectives: Reduce threat	Reduce damage	Protect economy	Emergency response	Maintain existing controls	Enhance existing controls	Maintain in-stream uses	Safe trans-portation	Equitable protection	Local control	Efficient public dollars	Overall effective-ness	Total Score	Priority by Area	Priority by Project
Rank of the Objectives	5	5	5	5	5	4	4	2	2	4	4	4			
Projects:															
Leveed Areas															
Maintain existing flood works	5	5	5	5	5	5	4	3	3	5	4	4	225	1	
Area 6 - Big ditch	4	4	4	2	4	4	3	2	2	4	4	4	174		5
Area 7 - Sloughed Levee	5	5	5	5	4	4	4	3	3	4	4	4	212		1
Coastal Areas															
Maintain existing flood works	5	5	5	5	5	5	0	1	0	4	4	4	195	10	
Area 8 - Padilla Dike	5	5	5	5	4	4	0	2	0	4	4	4	188		2
Urban/Rural Areas															
Maintain existing flood works	5	5	5	4	5	5	4	2	0	4	4	4	208	6	
Improve drainage way	5	5	5	3	4	4	4	3	1	4	4	4	198	7	
Area 12 - Gages Slough	4	4	5	2	5	5	3	2	0	4	4	4	184		3
Upper Skagit/Samish Valleys															
Maintain existing flood works	5	5	5	5	4	3	3	2	1	4	4	4	198	8	
Remove point bar accumulations	5	5	5	5	2	4	5	4	2	5	4	4	210	5	
Area 11 - Burlington	2	2	2	0	4	4	4	2	0	5	4	4	138		11
Area 3 - Lyman	3	3	2	0	1	1	4	2	0	5	4	4	121		12
Area 4 - Van Horn	2	2	2	0	1	1	4	4	0	5	4	4	115		14
Area 2 - Gilligans Creek	2	2	2	0	1	1	4	2	0	5	4	4	111		15
Stabilize banks	5	5	5	5	3	5	4	5	2	5	4	4	217	4	
Area 5 - Cape Horn Road	4	4	3	0	5	5	4	5	0	5	4	4	178		4
Area 10 - Hwy 9 Bridge	3	3	3	2	5	5	4	2	0	5	4	4	172		6
Specific education	3	3	2	3	4	4	3	1	1	4	4	4	155	12	
Area 13 - Cockreham Island	2	1	3	0	3	3	1	1	1	5	4	4	117		13
Area 14 - Hamilton	2	2	4	2	3	3	1	3	1	5	4	4	141		10
Feeder Streams															
Maintain existing flood works	5	5	5	5	4	4	5	5	2	5	4	4	222	2	
Holding pond	4	3	2	0	5	3	3	3	1	5	4	4	154	13	
Area 9 - Hansen Creek	3	3	2	1	5	5	3	3	1	5	4	4	162		7
Debris removal	3	2	2	3	5	5	5	5	2	5	4	4	181	11	
Area 15 - Grandy Creek	4	2	2	3	2	2	5	5	2	5	4	4	159		9
Bank stabilization	4	4	4	5	3	3	5	5	1	5	4	4	196	9	
Area 1 - Friday Creek	3	3	3	2	3	3	4	5	1	5	4	4	162		8
County-wide															
Enhance existing flood works	5	5	5	5	5	5	4	3	3	4	4	4	221	3	
Specific education	3	3	2	3	4	4	3	1	1	4	4	4	155	12	
Form additional drainage and diking districts	3	3	2	1	3	3	2	1	1	4	4	4	132	14	