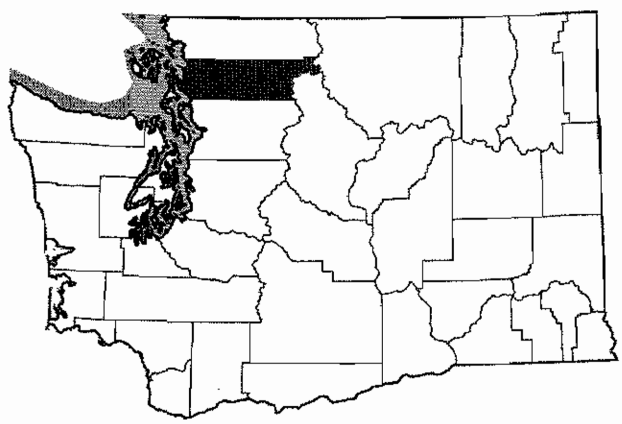
FLOOD INSURANCE STUDY

SKAGIT COUNTY, WASHINGTON
AND INCORPORATED AREAS

Community Name	Community Number
ANACORTES, CITY OF	530317
BURLINGTON, CITY OF	530153
CONCRETE, TOWN OF	530154
HAMILTON, TOWN OF	530155
LA CONNER, TOWN OF	530156
LYMAN, TOWN OF	530157
MOUNT VERNON, CITY OF	530158
SAUK-SUIATTLE INDIAN TRIBE	530340
SEDRO-WOOLLEY, CITY OF	530159
SKAGIT COUNTY (UNINCORPORATED AREAS)	530151
SWINOMISH INDIAN TRIBAL COMMUNITY	530222
*UPPER SKAGIT INDIAN TRIBE	530013

*Non-floodprone



Revised
Preliminary
Michael Baker, Jr., Inc.

JUN 30 2010

Federal Emergency Management Agency
FLOOD INSURANCE STUDY NUMBER
53057CV000A

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Selected Flood Insurance Rate Map panels for this community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways, cross sections). In addition, former flood hazard zone designations have been changes as follows:

Old Zone(s)	New Zone
A1 through A30	AE
V1 through V30	VE
B	X
C	X

The Federal Emergency Management Agency (FEMA) may revise and republish part of all of this FIS report at any time. In addition, FEMA may revise part of this FIS report by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS report. Therefore, users should consult with community officials and check the Community Map Repository to obtain the most current FIS report components.

This FIS report was revised on TBD. Users should refer to Section 10.0, Revisions Description for further information. Section 10.0 is intended to present the most up-to-date information for specific portions of the FIS report. Therefore, users of this report should be aware that the information presented in Section 10.0 supersedes information in Sections 1.0 through 9.0 of this FIS report.

Initial Effective Date: TBD

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FLOOD INSURANCE STUDY
SKAGIT COUNTY, WASHINGTON AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Skagit County, Washington, including the Cities of Anacortes, Burlington, Mount Vernon, Sedro-Woolley; the Towns of Concrete, Hamilton, La Conner, Lyman; the Sauk-Suiattle Indian Tribe, Swinomish Indian Tribal Community, Upper Skagit Indian Tribe, and the unincorporated areas of Skagit County (referred to collectively herein as Skagit County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the county that will be used to establish actuarial flood insurance rates and to assist the communities in their efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence, and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this FIS report are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

Pre-Countywide Analyses
The original hydrologic and hydraulic analyses for the City of Anacortes were performed by the United States Corps of Engineers (USACE), Seattle District, and Dames & Moore, for FEMA, under Inter-Agency Agreement No. IAA-H-7-76, Project Order No. 13, and Contract No. EMW-C-0542. That study was completed in December 1982 and was published for the unincorporated areas of Skagit County, Washington (Reference 1).

The original hydrologic and hydraulic analyses for the City of Burlington and the Town of La Conner were performed by the USACE, Seattle District and Dames & Moore, for FEMA, under Inter-Agency Agreement No. IAA-H-7-76, Project Order Nos. 2 and 20 , respectively; Inter-Agency Agreement No. IAA-2-10-77, Project Order No. 1; and Contract No. EMW-C-0542. That work was completed in December 1982 and covered all significant flooding sources affecting both Burlington and La Conner.

The original hydrologic and hydraulic analyses for the Town of Concrete, the Town of Lyman and the Town of Hamilton were performed by the USACE, Seattle District, for FEMA, under Inter-Agency Agreement No. IAA-H-7-76 and IAA-H-10-77, Project Nos. 20 and 1, respectively. The work for the Town of Concrete was completed in September 1980 and the work for the Town of Lyman and the Town of Hamilton was completed in October 1980.

The analyses covered all flooding sources affecting Concrete, Lyman and Hamilton.

The original hydrologic and hydraulic analyses for the January 5, 1982 study for Sedro Woolley were performed by the USACE, Seattle District, for FEMA, under Inter-Agency Agreement No. IAA-H-7-76, Project Order No. 20. That work was completed in November 1980 and covered all significant flooding sources affecting Sedro Woolley. The flooding in the southwest portion of Sedro Woolley was revised on December 5, 1989. The hydrologic and hydraulic analyses for that area were based on the Flood Insurance Study for Skagit County, Washington (Unincorporated Areas) dated October 17, 1984 (Reference 1).

The original hydrologic and hydraulic analyses for the City of Mount Vernon were performed by the USACE, Seattle District, and Dames & Moore, for FEMA, under Inter-Agency Agreement No. H-7-76, Project Order No. 20 and Contract No. EMW-C-0542. That work was completed in December 1982 and covered all significant flooding sources affecting Mount Vernon.

The original hydrologic and hydraulic analyses for the unincorporated areas of Skagit County were performed by the USACE, Seattle District, and Dames & Moore, under Inter-Agency Agreement No. IAA-H-7-76, Project Order No. 13 and Contract No. EMW-C-0542. That study was completed in December 1982 and covered all significant flooding sources affecting the unincorporated areas of Skagit County. The flooding for Skagit County (unincorporated areas) near the City of Sedro Woolley was revised on September 29, 1989. The revision resolved discrepancies in Special Flood Hazard Areas and zone designations between Skagit County and the city. Based on topographic data, the Special Flood Hazard Areas in Skagit County, located adjacent to the southwest corner of Sedro Woolley, were revised to reflect a Zone C (now known as a Zone X) flood designation. This designation is assigned to areas of minimal flooding.

The hydrologic and hydraulic analyses for Lakes Campbell and Erie were revised by Letter of Map Revision (LOMR) case number 00-10-083P. The study was conducted by the Hydrology and Hydraulic Section, Technical Services Branch, Engineering Division of the Seattle District USACE under the authority of Section 206 of the 1960 Flood Control Act as Amended. That LOMR was completed in April 7, 2000.

Countywide Analyses

The USACE, Seattle District, performed this restudy for FEMA pursuant to Interagency Agreements EMW-2002-IA-0113, Project Order No. 5 and EMW01-IA-0244-5. There are two distinct sections of the Skagit River that are being updated. The first section is the lower basin below the City of Sedro-Woolley, just downstream of the Highway 9 bridge, to the bays. This update only includes the floodplain and base flood elevations. A floodway for this lower area will be developed later in coordination with the communities. The second section is from the City of Sedro-Woolley up to the Town of Concrete. For this update, both the floodplain and floodway are completed.

As a result of the new hydrologic and hydraulic analyses for the Skagit River it was determined that the Skagit River floodplain will no longer influence flooding on the Samish River for about 3 miles below Highway I-5. The effective modeling for the Samish River extends upstream from Highway I-5 to the Skagit County border. In order to determine the flood hazards for the Samish River below Highway I-5 a search was conducted for previous flood related studies of this portion of the river. In 1995, CH2M Hill completed a study of the

Samish River from downstream of Highway I-5 to its confluence with Samish Bay. This report, titled "Lower Samish River Basin Comprehensive Flood Hazard Management Plan", was completed in June 1995. The report provided cross section locational information and a HEC-2 model. This information was used to determine the Zone A flooding on the Samish River downstream of Highway I-5.

1.3 Coordination

Pre-Countywide Analyses

An initial coordination meeting with the communities was held in the City of Mount Vernon on November 20, 1975, between representatives of the study contractor, FEMA, the Washington State Department of Ecology, and local representatives to inform the communities of the nature and purpose of the FIS, to solicit map data, and to establish the scope of the study. Additional coordination on the scope of the study and study methods was conducted with local representatives, the study contractors, and FEMA throughout the study period.

The results for the Towns of Concrete, Hamilton, and Lyman studies were reviewed at intermediate meetings attended by representatives of the study contractor and community officials on April 21, 1980 and August 26 and 27, 1980, respectively. The studies were acceptable to the communities.

For the Cities of Burlington and Mount Vernon, the Town of La Conner, and Skagit County, intermediate coordination meetings were held on March 21 and 23, 1983, and were attended by representatives of FEMA, the study contractors, and the communities to discuss the study. All appropriate changes resulting from the meeting have been included in this report.

Final community coordination meetings were held on April 6, 1981, for the Town of Hamilton and on August 13, 1981, for the City of Sedro-Woolley and the Towns of Concrete and Lyman. The meetings were attended by representatives of FEMA, the study contractor, and the communities. No problems were raised at the meetings.

Final community coordination meetings were held on December 6 and 8, 1983 and January 10, 1984, respectively, for the Cities of Mount Vernon, Burlington, and the Town of La Conner, and were attended by representatives of FEMA, the study contractor, and the communities. There were no problems raised that would effect the content of the FIS.

The final community coordination meeting for Skagit County was held on June 14, 1984, and was attended by representatives of FEMA, the study contractor, and the county. There were no problems raised that would effect the content of the FIS.

The results of the City of Anacortes study were reviewed at the final Consultation Coordination Officer (CCO) meeting held on December 14, 2001, and was attended by representatives of FEMA and the community. All problems raised at that meeting have been addressed in the 2003 study.

The Swinomish Indian Tribe, the Upper Skagit Indian Tribe and the Suak Suiattle Indian Tribe do not have previously printed FIS reports.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS report covers the geographic area of Skagit County including the incorporated communities listed in Section 1.1. The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development. Table 1 lists all streams studied by detailed methods, the completion date for the study, the study contractor and the studied reach.

Table 1. Streams Studied by Detailed Methods

River	Completion Date	Study Contractor	Studied Reach
Baker River	December 1982	USACE – Seattle District	From confluence with Skagit River to River Mile (RM) 0.9
Cascade River	December 1982	USACE – Seattle District	From confluence with Skagit River to upper end of Cascade River Park at RM 5.8
Samish River	June 1995	CH2M Hill	Edison Road Bridge to I-5 (RM 8.5)
	December 1982	USACE – Seattle District	From I-5 (RM 8.5) to the Skagit-Whatcom County line at RM 26.0
Sauk River	December 1982	USACE – Seattle District	From confluence with Skagit River to the Skagit-Snohomish County line at RM 17.0
Skagit River	April 2008	USACE – Seattle District	From the Highway 9 Bridge near the City of Sedro-Woolley (approximately RM 22.4) to split into North Fork and South Fork Skagit River
	June 2009	USACE – Seattle District	From the Highway 9 Bridge near the City of Sedro-Woolley to the Town of Concrete (approximately RM 22.4 to RM 56.61 (cross section AT)
	December 1982	USACE – Seattle District	From the Town of Concrete (approximately RM 56.61) to the boundary of Ross Lake National Recreation Area at Bacon Creek at RM82.3
North Fork Skagit River	April 2008	USACE – Seattle District	From split of Skagit River into North Fork and South Fork to confluence with bay
South Fork Skagit River	April 2008	USACE – Seattle District	From split of Skagit River into North Fork and South Fork to confluence with bay
Suiattle River	December 1982	USACE – Seattle District	From confluence with the Sauk River to RM 5.1 and from RM 10.6 to the Skagit-Snohomish County Line at RM 12.2

Tidal flooding from Burrows, Skagit, Similk, Samish, Padilla, and Fidalgo Bays, Rosario Strait, and Bellingham, Swinomish, and Guemes Channels affecting mainland shorelines and Allans, Burrows, Cypress, Hope, Goat, Guemes, Ika, Sinclair, Vendovi, Hat, and Samish Islands was also studied by detailed methods. These flooding sources were studied by the USACE Seattle District in December 1982.

The following rivers and lakes were studied by approximate methods: the Suiattle River from RM 5.1 to RM 10.6., Lake Erie, Lake Cavanough, Lake McMurray, Beaver Lake, Clear Lake, and Big Lake. These flooding sources were studied by the USACE Seattle District in December 1982.

Lake Campbell was also studied by the USACE Seattle District in December 1982, but was revised by Letter of Map Revision dated April 7, 2000 to show the results of a detailed analysis. This revision was incorporated as part of the countywide mapping.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon, by FEMA and Skagit County.

2.2 Community Description

Skagit County, in northwestern Washington State, is bordered by the Puget Sound on the west and the rugged Cascade Range, rising to 8,000 feet, on the east. It is surrounded by Whatcom County to the north, Okanogan and Chelan Counties to the east, Snohomish and Island Counties to the south, and San Juan County to the west. The county encompasses 1,735 square miles. The first white settlers came to Fidalgo Island in the late 1850s. Settlement of the tide flats on the mainland soon followed. Clearing and diking of the tide flats created rich farmlands which yielded fine crops of grains and vegetables. In the 1870s, there was a rapid influx of families to the region; schools, churches, and other signs of civilization soon followed. By the 1890s, farming, logging, and commercial fishing activities were well-established. Skagit County was established in 1884 and named after the river and the Skagit Indian Tribe which lived along the riverbanks (Reference 2).

Skagit County's economy has grown steadily and it is historically regarded as one of the fastest growing areas in the State of Washington. The national trend toward employment in retail trades and personal and professional services is evident in Skagit County with malls and a presence of almost every national retail chain. Agriculture, fishing, wood products, tourism, international trade, and specialized manufacturing make up the economy of Skagit Valley. With its accessible ports and refineries, Skagit County is the center of the state petroleum industry. Table 2 illustrates the change in population over since 1980 for all incorporated cities, towns and the unincorporated areas of the county.

Table 2. Population Figures for Skagit County and Incorporated Cities

Community	1980[1]	1990[2]	2000 Census[2]
City of Anacortes	*	11,451	14,557
City of Burlington	3,910	4,349	6,757
Town of Concrete	600	735	790
Town of Hamilton	262	228	309
Town of La Conner	660	656	761
Town of Lyman	325	275	409
City of Mount Vernon	13,280	17,647	26,232
Skagit County (unincorporated areas)	32,113	38,138	44,506
City of Sedro Woolley	5,600	6,031	8,658

*not available
[1] Reference 3
[2] Reference 4

City of Anacortes

The City of Anacortes became an incorporated city in 1891. Incorporation came at a high point during the early beginnings of the settlement, which was founded in the shelter of Ship Harbor in the 1870s. In 1889, the quiet settlement was thrust into a boom period based on speculation that a western terminal of the transcontinental railroad would be developed in the city to take advantage of the area's natural, deep water harbor. In less than a year, by March of 1980, the population swelled from 100 to 3,000. The railroad terminus failed to materialize and the boom soon passed, bottoming out with the economic crash of 1893. By the late 1890s, Anacortes and the country began recovering from the economic crash, and the city's prosperity was now based on the local natural resources of lumber and fisheries. At the turn of the 20th century, Anacortes' population was 1,476.

From 1900 to 1950, growth of Anacortes' economy and a population of 6,919 were dependent upon those same resources. In the 1950s, technological changes and resource depletion were beginning to erode the strength of the local natural resource base, when two new factors were introduced to the local economy. These were petroleum refining and tourism and marina activity. In the early 1950s, with a decline in wood products and fisheries, the population of Anacortes began to decrease. However, in 1953, with the development of Shell and Texaco refineries on March Point, population growth resumed an upward trend. Since 1960, the major industrial economic development project in the area has been the completion of the Industrial Redevelopment Area on Fidalgo Bay. Another important and rapidly expanding element of the local economy in the past two decades has been the tourism and marina business. Since 1970, Anacortes has been experiencing slow to moderate population and economic growth (Reference 5).

Anacortes is located on the northern end of Fidalgo Bay. It covers approximately 14 square miles, with development spread along the western, eastern, and northern shorelines and at March Point. Approximately half the community is designated as city park and forest recreational areas, with most of these sites in the central and southern areas of the city. The city is bounded on three sides by 12.5 miles of saltwater shoreline along Burrows Bay, Rosario Strait, Guemes Channel, and Fidalgo Bay. There are four freshwater lakes: Cranberry Lake, Cannery Pond, Whistle Lake, and Heart Lake.

Elevations within the city vary from sea level to 600 feet in the southwest quadrant and to 1,270 feet at the top of Mount Erie, which offers a commanding view of the surrounding region. Anacortes, with its gently sloping topography, offers extraordinary marine vistas from numerous spots within the city boundaries and unique opportunities for shoreline access and water-related activities.

The temperatures in Anacortes are relatively mild. Daytime summer temperatures are in the 70s, with nighttime temperatures in the 50s. Maximum temperatures reach 80° F to 85° F, although a few 90° F to 100° F days have been recorded. The highest temperatures and lowest relative humidity are recorded during periods of easterly winds. December and January are the coldest months, with average temperatures in the upper 30s.

The prevailing wind direction is from the southeast in the winter and from the southwest in the summer. During late spring and summer, a prevailing westerly and northwesterly flow of air in the Puget Sound brings a dry season that begins in May and peaks in July. In late fall and winter, a prevailing southwesterly and westerly air flow from the Pacific Ocean results in a wet season beginning in October that lasts until the dry season begins in May. During winter, the combined influences of low-pressure systems off the Pacific Coast and cold air from the Fraser River Canyon produce strong northeasterly winds. Although it is not uncommon to have 30 to 40 knot winds under these conditions, the short fetch in the Anacortes area usually limits wind generated wave heights to no more than six feet (Reference 6).

The Naval Air Station on Whidbey Island has recorded gusts up to 73 miles per hour and sustained westerly velocities up to 54 miles per hour (data from the National Weather Service).

Total precipitation for December is less than 1.9 inches in one winter out of 10; it exceeds 6.5 inches in one winter out of 10. Annual precipitation is between 18 and 33 inches. Most winter precipitation is rain, but it is not uncommon to have three to 10 inches of snow. Thunderstorms occur five to 10 days a year. Most occur during the summer, but they have been recorded in each month of the year.

City of Burlington

The City of Burlington is located in the west-central portion of Skagit County in northwestern Washington. It is situated immediately north of Mount Vernon. Transportation facilities include Interstate Highway 5, State Highway 20, and the Burlington Northern Railroad.

Burlington was first settled in 1882 by John R. Millett and William McKay, who operated a logging camp at the present site of the community. Tom W. Soules, who purchased the land from McKay, named the settlement for Burlington, Vermont. Extensive logging operations in the valley and the adjacent foothills led to the construction of a large sawmill in 1890, and the Seattle and Northern Railway extended its lines to the town. For a number of years, Burlington grew due to its position at the crossroads of railway lines and proximity to timber stands. The depletion of the timber stands eventually forced a change from logging and lumbering to dairying and farming (Reference 7). Burlington is located in the heart of a rich agricultural area with a mild climate and good soils well-suited to vegetable, seed, berry, and bulb production (Reference 8).

Burlington is located on the right bank of the Skagit River valley, with elevations ranging from approximately 20 feet in the southern part of the city near the river to approximately 260 feet on Burlington Hill in the northern part of the city. Most of the land surrounding Burlington has little topographic relief because it is a part of the low-lying delta of the Skagit River. Burlington Hill, on the northern part of the city limits, has an elevation of approximately 460 feet and represents the major topographic feature in the area. Underlying Burlington are alluvial soils consisting primarily of fine sandy loam. Most of the land within the corporate limits has been cleared of native vegetation. In the few wooded areas, deciduous trees such as alder, maple, willow, and cottonwood predominate, except on Burlington Hill where Douglas fir predominates (Reference 9).

The climate is predominantly mid-latitude, west coast, and marine because most of the air masses originate over the Pacific Ocean. In late fall and winter, these masses are moist and at approximately the same temperature as the ocean surface. Orographic lifting and cooling as air masses are carried inland by prevailing westerly winds results in cloudiness and widespread precipitation throughout Skagit County. Burlington receives an average of approximately 36 inches of precipitation annually, of which approximately 50 percent falls from October through January. Average annual snowfall is approximately five inches and average temperatures range from 39° F in January to 69° F in August (Reference 10).

The old United States Highway 99 Bridge (Garl Street) near the southern corporate limits of Burlington is 147 miles from the source of the Skagit River, and the drainage area above this point is 3,093 square miles.

Town of Concrete

The Town of Concrete is located in the north-central portion of Skagit County in northwestern Washington State. It is situated approximately 25 miles east of Sedro-Woolley and 30 miles northeast of Mount Vernon. Concrete is served by State Highway 20, a spur of the Burlington Northern Railroad, and a municipally owned and operated airfield.

Concrete was founded in 1890 by Magnus Miller who originally named the settlement Baker, for the river which enters Skagit River at this point. The Miller home served as a hotel, store, community center, and post office. In 1901, the Baker River Lumber Company erected a shingle mill, company store, and other buildings, and the community began to flourish. The establishment of a lime quarry and cement plant in 1905 led to the town being renamed Cement City and later Concrete (Reference 11). Since the closure of its last operating cement plant in 1969 (Reference 12), the economy of the town has relied principally on the logging and lumbering industry.

Built partially on a hillside on the right bank of the Upper Skagit River valley, elevations in Concrete vary from 160 feet at the confluence of Baker and Skagit Rivers to approximately 600 feet in the northwest corner of the town. Mountains ranging from 3,000 to 4,000 feet in elevation define both sides of the Skagit River valley in the vicinity of Concrete. Soils vary from riverwash and loamy sand near the river channels to silt loam and gravelly sandy loam approaching the valley sides. Most of the land within the corporate limits of Concrete is cleared. Although the floodplain has little development, there are several residences near the mouth of Baker River.

Near the river channels, the land is covered either with second growth deciduous species such as red alder, big leaf maple, or vine maple, or with virgin forest species such as Douglas fir, western hemlock, Sitka spruce, or western red cedar (Reference 9).

The climate of Concrete is predominately mid-latitude, west coast, and marine because most of the air masses that reach the area originate over the Pacific Ocean. In late fall and winter, these air masses are moist and at approximately the same temperature as the ocean surface. Orographic lifting and cooling as air masses move inland result in cloudiness and widespread precipitation over Concrete and the surrounding area. Concrete experiences an average of 67.2 inches of rainfall annually, of which 50 percent falls from October through January, and 75 percent falls from October through March. Average annual snowfall is 33.5 inches. Average temperatures range from 36.4° F in January to 65.6° F in July. The highest and lowest recorded temperatures in Concrete were 106° F and -1° F, respectively (Reference 10).

The Skagit River flows westerly to Puget Sound and is the principal river of Skagit County. The gaging station at Dalles Bridge, near the downstream corporate limits of Concrete, is 108 miles from the source of the Skagit River and the drainage area above this point is 2,737 square miles. The majority of the river is south of Concrete. However, the river forms the southern corporate limits from the confluence of Baker River upstream for approximately 0.3 mile.

The Baker River, a tributary flowing southerly to the Skagit River through the eastern portion of Concrete, is 29.6 miles in length, with a drainage area of 297 square miles. Runoff per unit area from the Baker River is somewhat higher than runoff from other Skagit River tributaries because the Baker River basin receives heavier precipitation from the initial lifting of Pacific air masses over the Cascade Range. This also reduces the precipitation on the Upper Skagit River basin due to a rain shadow effect. Average annual runoff from the Baker River at Concrete is approximately 120 inches per year in comparison to only 50 inches per year from the Skagit River above Newhalem.

Town of Hamilton

The Town of Hamilton is located in north-central Skagit County, in northwestern Washington. It is approximately 11 miles east of Sedro-Woolley and approximately 12 miles west of Concrete. Lyman is approximately three miles west of Hamilton along the Skagit River. Unincorporated Areas of Skagit County surround Hamilton. Transportation facilities include State Highway 20 and a spur of the Burlington Northern Railroad.

Coal seams were discovered on the south bank of the Skagit River near Hamilton in 1875. In 1877, William Hamilton, for whom the town is named, first filed on the land which later became the town site. In 1884, he started a general store and post office.

The first railroad reached Hamilton in 1891 to haul coal from the Hamilton mines (Reference 2). Today, the economy of the town depends principally on the timber industry and farming.

Hamilton is located in the Skagit River valley. The topography is nearly level, with elevations ranging from 87 feet next to the river to 113 feet in the extreme northwest part of the town. Mountains 3,000 to 4,000 feet in elevation define the Skagit River valley in the vicinity of Hamilton. At least 90 percent of Hamilton is between 90 and 100 feet in elevation. Hamilton is underlain by bottom-land soils ranging from fine sand to loam which were deposited by the river. Most of the land within Hamilton is cleared and covered with grass. Near the river and in areas with sufficient soil moisture, the vegetation is primarily deciduous with species of alder, maple, willow, cottonwood, brush, and vines (Reference 9).

The climate is predominantly mid-latitude, west coast, and marine because most of the air masses that reach the area originate over the Pacific Ocean. In late fall and winter, these air masses are moist and at approximately the same temperature as the ocean surface. Orographic lifting and cooling as air masses are carried inland by prevailing westerly winds result in cloudiness and widespread precipitation over Hamilton and the surrounding area. Hamilton has an average of 60 inches of rainfall annually, of which 50 percent falls from October through January, and 75 percent occurs from October through March. Average annual snowfall is 20 inches. Average monthly temperatures range from 37° F in January to 65° F in July (Reference 10).

The Skagit River, as it flows westerly, forms the southern corporate limits of Hamilton and represents the major flooding source of the community. Hamilton is 122 miles from the headwaters of the river, and the upstream drainage area is approximately 3,000 square miles. There is commercial development, but residential development dominates the area within the floodplain of the Skagit River in Hamilton.

Town of La Conner

The Town of La Conner is located near the western boundary Skagit County, in northwestern Washington. It is situated approximately 10 miles southwest of Mount Vernon and served by various county roads.

La Conner is bounded on the west by the Swinomish Channel and on the east by Sullivan Slough, which are both connected to Skagit Bay.

Built on the site of the first trading post on Swinomish Slough, La Conner was known as Swinomish in the early 1860s (Reference 11). In 1869, John S. Conner began a mercantile business and renamed the town La Conner in honor of his wife, Louisa A. Conner.

In its early days, La Conner prospered as a mercantile and shipping center. Its proximity to nearby croplands and to water made it a natural shipping terminus (Reference 13). The town became the site of a large mail-order seed business and also served as the temporary county seat after the formation of Skagit County (Reference 2). The economy of La Conner is based on fishing, farming, retailing, and tourism. The latter is promoted by the architectural style and scenic location of the town.

Located on the eastern bank of the Swinomish Channel, elevations within La Conner range from approximately sea level along the channel to approximately 140 feet in the southwestern portion of town. La Conner is at the western edge of the low-lying delta of the Skagit River. Underlying La Conner are silt loam soils developed from fine-textured recent alluvium (Reference 9). Most of the land within La Conner is cleared, except for two rock outcroppings that support an abundance of flora (Reference 14).

The climate is moist and mild due to the moderating effect at lower elevations of the prevailing westerly winds from the Pacific Ocean. La Conner receives approximately 24 inches of rainfall annually, of which almost 75 percent falls from October through March.

Average temperatures range from approximately 39° F in January to 62° F in July (Reference 15).

Town of Lyman

The Town of Lyman is located in north-central Skagit County, in northwestern Washington. It is approximately eight miles east of Sedro-Woolley and approximately 15 miles west of Concrete. Hamilton is approximately three miles east of Lyman along the Skagit River. Unincorporated Areas of Skagit County surround Lyman. Transportation facilities include State Highway 20 and a spur of the Burlington Northern Railroad.

Lyman was platted in 1884 and named for B. L. Lyman, the first postmaster (Reference 2). The economy of Lyman depends principally on residents who are employed in logging, lumbering, and farming.

Located on the right bank of the Skagit River valley, elevations within Lyman range from 67 feet along the river to 97 feet in the south-central portion of the town. Mountains 3,000 to 4,000 feet in elevation define the Skagit River valley in the vicinity of Lyman. Underlying Lyman are bottom land soils, ranging from fine sand to loam, which were deposited by the river. Most of the land within the corporate limits of Lyman is cleared and vegetated with grass. Near the river and in areas with sufficient soil moisture, the vegetation is primarily deciduous, with species of alder, maple, willow, cottonwood, brush, and vines (Reference 9).

The climate of Lyman is predominantly mid-latitude, west coast, and marine, because most of the air masses that reach the area originate over the Pacific Ocean. In late fail and winter, these air masses are moist and at approximately the same temperature as the ocean surface. Orographic lifting and cooling as air masses are carried inland by prevailing westerly winds result in cloudiness and widespread precipitation over Lyman and the surrounding area. Lyman experiences an average of 50 inches of rainfall annually, of which 50 percent falls from October through January and 75 percent falls from October through March. Average annual snowfall is approximately 20 inches. Average temperatures range from 40° F in January to 60° F in July (Reference 10).

The Skagit River forms the southern corporate limits of Lyman as it flows westerly and represents the major flooding source of the community. Lyman is 128 miles from the headwaters of the river, and the upstream drainage is approximately 3,000 square miles. The floodplain in Lyman is relatively free of development.

City of Mount Vernon

The City of Mount Vernon is located in the west-central portion of Skagit County in northwestern Washington State. It is the county seat of Skagit County and is located 62 miles north of Seattle and 27 miles south of Bellingham. Mount Vernon is adjacent to Burlington to the north and surrounded by Unincorporated Areas of Skagit County to the east, south, and west. Transportation facilities include Interstate Highway 5, State Highways 536 and 538, and the Burlington Northern Railroad.

In 1870, Joseph Dwelley and Jasper Gates took up the first claims in the area where Mount Vernon now stands. At this time, the Skagit River was blocked by log jams above and below the present site of Mount Vernon, but by 1876 the work of cutting through the jams had begun. A channel was cut through the lower jam in 1877, and in the same year Harrison Clothier and E. G. English purchased 10 acres from Jasper Gates and erected a general store and post office. Clothier and English laid out the first plat of the town site and named the plat after George Washington's Potomac River estate. A channel cut through the upper jam in 1879 opened up logging areas along the Upper Skagit River. The Ruby Creek gold excitement of 1879 and 1880 greatly increased boat traffic and business in Mount Vernon (Reference 2). In 1884, Mount Vernon was selected by the voters of the county as the permanent county seat, and the arrival of the Great Northern Railway in 1891 consolidated a position of eminence for Mount Vernon (Reference 16).

As logging activities around Mount Vernon moved eastward to the foothills of the Cascade Mountains, farming became the economic backbone of the area, and Mount Vernon steadily grew as a center of retailing and food processing. Mount Vernon is located in the heart of a rich agricultural area with a mild climate and good soils well-suited to vegetable, seed, berry, and bulb production. Dairying and beef production are other important agricultural industries (Reference 9).

Located on the left and right banks of the Skagit River valley, elevations within Mount Vernon range from approximately 10 feet in the southwestern part of the city along the river to approximately 200 feet in the southeastern part of the city. Mount Vernon is at the eastern edge of the low-lying delta of the Skagit River and to the east of Mount Vernon are the foothills of the Cascade Mountains. Underlying Mount Vernon are two main groups of soils. Near the river are alluvial soils consisting of fine, sandy loam and loam, and away from the river are glaciated, upland soils consisting of gravelly loam and loam. Most of the land within the corporate limits has been cleared of native vegetation. In areas with vegetation, grass and deciduous trees such as alder, vine maple, and willow predominate. Some areas also contain second growth Douglas fir (Reference 10).

The climate is predominantly mid-latitude, west coast, and marine because most of the air masses originate over the Pacific Ocean. In late fall and winter, these air masses are moist and at approximately the same temperature as the ocean surface. Orographic lifting and cooling as air masses are carried inland by prevailing westerly winds result in cloudiness and widespread precipitation throughout Skagit County. Mount Vernon receives an average of approximately 32 inches of precipitation annually, of which approximately 75 percent falls in from October through February. Average annual snowfall is approximately five inches. Average temperatures range from 39° F in January to 69° F in August (Reference 17).

The old United States Highway 99 Bridge (Riverside Drive) near the corporate limits of Mount Vernon is 147 miles from the source of the Skagit River, and the drainage area above this point is 3,093 square miles.

<u>Sauk-Suiattle Indian Tribe</u>
The Sauk-Suiattle Indian Tribe's traditional territory was the entire drainage area of the Sauk, Suiattle and Cascade Rivers with an important village at Sauk Prairie near the confluence of the Sauk and Suiattle Rivers. This village was destroyed in 1884 by early non-Indian settlers laying claim to the land through the U.S. Homestead Act. Although the tribe became landless the tribal government was maintained (Reference 18).

The landless Sauk-Suiattle Indian Tribe managed to survive in dispersed groups near their ancestral homelands. Numerous tribal members moved away or were assimilated by nearby tribes, but a remnant held together on the strength of its culture and tribal government. Before

1855, tribal membership was estimated to be around 4,000, but their numbers dwindled to fewer than 20 by 1924.

A dozen years later, the Sauk-Suiattle Indian Tribe submitted a suit against the federal government's Court of Claims to claim redress for lands withdrawn under the Point Elliott treaty. The court rejected the suit. The tribe re-submitted the suit, this time to the Indian Claims Commission. The latter also dismissed it because the tribe was held to be indistinguishable from the Upper Skagit tribe at the time of the treaty.

Nevertheless, the Sauk-Suiattle Indian Tribe was finally federally recognized as a sovereign tribal governing entity on September 17, 1975. They were granted reservation status on July 9, 1984, beginning with a 15-acre reservation

Today's tribal membership hovers at around 230, most of who reside on the reservation. The modern reservation comprises 84 acres, of which 23 are in trust and the remaining acreage is being placed in trust. A seven-member council conducts tribal affairs according to the constitution and bylaws, fishing, election ordinances, and law and order codes. They serve staggered three-year terms (Reference 19).

City of Sedro-Woolley

The City of Sedro-Woolley is located in west-central Skagit County, in northwestern Washington State. The city is approximately five miles east of Burlington. Sedro-Woolley is at the intersection of State Highways 7, 9, and 20 and is also served by the Burlington Northern Railroad.

The community was settled in 1878 by David Batey and Joseph Hart, who sold 40 acres to Mortimer Cook in 1884. Mr. Cook laid out a town site and intended to "bestow upon the new town a name such as no other town in America should have, and if such could be found he cared little whether or not it was euphonious or elegant." He eventually concluded to name the place "Bug" (Reference 20). Outraged settlers threatened to add the prefix "hum" to the town sign before townswomen finally convinced Cook to rename the town Sedro, from the Spanish word *cedro*, meaning "cedar." Because of its strategic location, the town became the head of navigation on the Skagit River and prospered, particularly during the Mount Baker gold rush days. In 1889, the Great Northern and Northern Pacific Railroads established a junction north of Sedro, and P. A. Woolley platted a town site at the crossing bearing his name. To mitigate the high costs of duplicate governments, the adjacent towns were incorporated (with a now-forgotten hyphen) as Sedro-Woolley in 1890 (Reference 21).

Sedro-Woolley is the center of a region that has successfully accomplished the transition from large-scale logging and lumbering to farming. The area supports a large number of fruit, vegetable, dairy, and poultry farms. Within the corporate limits, there is a heavy equipment manufacturing firm, an electronics equipment firm, two lumber mills, and numerous small commercial businesses.

Located on the right bank of the Skagit River valley, elevations within Sedro-Woolley range from 36 to 56 feet. To the east are the foothills of the Cascade Range, rising to 4,000 feet in elevation, and to the west is the low-lying Skagit River delta. Underlying Sedro-Woolley are bottom-land soils consisting of silt loam and fine sandy loam which were deposited by the river. Most of the land within Sedro-Woolley is cleared. In areas with sufficient soil moisture, the vegetation is primarily deciduous with species of alder, maple, willow, cottonwood, brush, grass, and vines (Reference 9).

The climate of Sedro-Woolley is predominantly mid-latitude, west coast, and marine because most of the air masses that reach the area originate over the Pacific Ocean. In late fall and winter, these air masses are moist and at approximately the same temperature as the ocean surface. Orographic lifting and cooling as air masses are carried inland by prevailing westerly winds result in cloudiness and widespread precipitation over Sedro-Woolley and the surrounding area. Sedro-Woolley has an average of 46 inches of rainfall annually, of which 50 percent falls from October through January, and 75 percent falls from October through April. Average annual snowfall is 11 inches. Average monthly temperatures range from 38° F in January to 63° F in July. Record temperatures include a high of 99° F and a low of -20° F (Reference 10).

Swinomish Indian Tribal Community

The Swinomish Indian Tribal Community's traditional territory included the area now referred to as Skagit, San Juan, and Island Counties. Each family group had permanent villages but contemporary concepts of land ownership were not recognized. In the middle of the nineteenth century, white settlers began to arrive, claiming vast tracts of land for farms and homesteads. Responding to growing pressures the state and federal government called a meeting of local tribal leaders in Mukilteo. As a result of the meeting, the Treaty of Point Elliott was signed on January 22, 1855. The Treaty established the Swinomish Reservation as a permanent homeland for the Swinomish, Kikiallus, Samish, and Lower Skagit Tribes. The Swinomish Indian Tribal Community's reservation is located on Fidalgo Island, west of the Swinomish Channel near LaConner, Washington.

At the end of the nineteenth century, reservation land was taken out of communal tribal ownership and transferred to individual ownership. Today, the Swinomish Indian Tribal Community owns approximately 4% of the reservation land base and approximately 2,900 acres of the tidelands around the perimeter of the reservation. Individual tribal members own 50% of the land base, approximately 20 percent of which is leased to non-Indians.

The Swinomish Indian Tribal Community is federally recognized and operates under Constitution and Bylaws adopted in 1936 pursuant to the Indian Reorganization Act of 1934. Tribal regulatory authority includes land use planning, environmental assessment and regulation of land, water and air resources, and sustainable reservation economic development.

The General Council, comprised of all voting age members of the Swinomish Indian Tribal Community, meets on a regular basis to address issues facing Swinomish (Reference 22).

Upper Skagit Indian Tribe

The Upper Skagit Indian Tribe's tradition territory consisted of lands along the Skagit River from the current location of the City of Mount Vernon to as far north as Newhalem as well as lands on the Baker and Sauk Rivers (Reference 23).

The Upper Skagit Indian Tribe was among the signatories to the Point Elliott Treaty of 1855. The government said the Upper Skagit were not one group, they were villages that made up the Upper Skagit. Surveyors from the Northern Pacific Railroad crossed Upper Skagit land in 1870 and white settlers came soon after. The Upper Skagit people were angered when settlers crossed on the lands that held their dead. The Upper Skagit people suffered from diseases from white contact. Their ancestors eventually consolidated, but a separate reservation was not originally established, and some tribal members had to reside on other reservations, primarily Swinomish. The Tribe received formal federal recognition in early 1970s, with land put into trust for the tribe in 1984 (Reference 24).

The Upper Skagit Indian Tribe's reservation covers an 84-acre parcel of land east of Sedro Woolley in Skagit County. An additional 15 acres of non-developed commercial land is located along Interstate 5 near the town of Alger. The reservation is located in the Cascade foothills. The Upper Skagit Indian Tribe is governed by a seven member Tribal Council elected in accordance with the Tribal Constitution and by-laws approved by the Secretary of the Interior in 1974. Council members serve for staggered three-year terms (Reference 25).

The Skagit River Basin

The Skagit River basin is located in the northwest corner of the State of Washington. The Skagit River drainage area is 3,115 square miles and the basin extends approximately 110 miles in the north-south direction and approximately 90 miles in the east-west direction between the crest of the Cascade Range and Puget Sound. The northern end of the basin extends 28 miles into Canada.

The Skagit River originates in a network of narrow, precipitous mountain canyons in Canada and flows west and south into the United States where it continues 135 miles to Skagit Bay. The Skagit River falls rapidly from its source to an elevation of 1,600 feet at the United States-Canadian Border. Stream profiles on show that within the first 40 miles south of the International Border, the river falls 1,100 feet and that the remaining 500-foot fall is distributed along the 95 miles of the lower river.

The Skagit River crosses a broad outwash plain between Sedro Woolley and the river mouth. Immediately downstream from the City of Mount Vernon, the river divides into two principal distributaries, the North Fork and the South Fork. These two distributaries carry about 60 percent and 40 percent of the normal flows of the Skagit River, respectively.

The Skagit Valley, the 100,000 acre valley area downstream from Concrete, contains the largest residential and farming developments in the basin. The 32 mile-long valley between Concrete and Sedro Woolley is made up of mostly cattle and dairy pasture land and wooded areas. West of Sedro Woolley, the floodplain forms a large alluvial fan with an east-west width of about 11 miles and a north-south width of about 19 miles (Reference 26).

A major portion of the Skagit River basin lies on the western slopes of the Cascade Range. Most of the eastern basin is mountainous land above an elevation of 6,000 feet. The two most prominent topographical features in the basin are Mount Baker at an elevation of 10,778 feet on the western boundary of the Baker River basin and Glacier Peak at an elevation of 10,568 feet in the Sauk River sub-basin. In the eastern basin, 22 peaks are above an elevation of 8,000 feet. The upper reaches of nearly all tributaries are situated in precipitous, steep-walled mountain valleys.

The Skagit River flows in a one-mile to three-mile wide valley from Rockport to Sedro Woolley. In this section, the valley walls are moderately steep, timbered hillsides with few developments. Below Sedro Woolley, the valley falls to nearly sea level and widens to a flat, fertile outwash plain that joins the Samish valley along the northeast side of the valley and extends west through Mount Vernon to La Conner and south to the Stillaguamish River

(Reference 27).

Overstory vegetation in the mountains and foothills of eastern Skagit County is dominated by western hemlock and Douglas fir. Moving westward, many different deciduous trees and shrubs are mixed with conifers, including alder, maple, willow, and cottonwood. The broad floodplain in the western part of the county and the delta is predominantly cultivated land or pasture. Urban areas contain scattered conifers, deciduous trees, shrubs, and grasses (Reference 9).

The eastern mountainous region of the upper Skagit River basin consists of ancient metamorphic rocks; largely phyllites, slates, shales, schists, and gneisses together with intrusive granitic rocks and later andesitic lavas and pyroclastic deposits associated with Mount Baker and Glacier Peak. The valleys are generally steep-sided and frequently flat-floored. Valley walls are generally mantled with a mixture of rocky colluvium, and to a considerable elevation, by deposits of continental and alpine glaciation. These deposits are a heterogeneous mixture of sand and gravel together with variable quantities of silt and clay depending on the mode of deposition. Some of these deposits are highly susceptible to land sliding when saturated.

The floodplain of the Skagit River below Concrete is composed of sands and gravels that diminish to sands, silts, and some clay further downstream. Below Hamilton, fine-grained floodplain sediments predominate. The Baker River valley in the vicinity of the Baker Lake is geologically quite different from most of the other Skagit tributaries. This is largely due to the influence of Mount Baker, a volcanic cone rising to an elevation of 10,778 feet that sets astride the western boundary of the Baker River basin.

Present bedrock exposures adjacent to Ross Lake consist of Chilliwack sediments, volcanics and granitics, Skagit gneiss, and Nooksack group phyllite. The continental ice movement and mountain glaciers sculpted the basic geological forms and rock types into the major landforms that are recognizable today. A large mass of metamorphic rock, known as the Skagit gneiss, forms the foundation rock for all three of the Skagit River Project plants. The age of its parent strata is presumed to be Paleozoic. The resistance to erosion provided by the massive gneiss is undoubtedly the reason for the narrow gorge of the Skagit River where the dams are located. Alpine glaciers have contributed to the steepness of the valley sides and to the depth of the valley bottoms. Over ten thousand years ago the upper Skagit Valley and the peaks were severely glaciated, removing not only the soil, but much of the loose rock. Many river channels created during the glacial melt have continued to aggrade, and as a result of that glacial action, the bedrock bottoms of most canyons are covered with glacial alluvium.

Predicted rates of bed accumulation for 100 years in the Skagit River system vary in depth from four feet at the mouth of the two distributaries, the North and South Forks of the Skagit River, to two feet at Mount Vernon. The two feet of depth continues upstream to Burlington. The Skagit River annually transports about 10,000,000 tons of sediment of mostly glacial origin. The size of bed material, as determined by field observations and samples, varies from a quarter-inch to three quarters-inch gravel and coarse sand at Mount Vernon to medium and fine sand near the river mouths. From Burlington to Concrete, channel sediments are predominantly fine-to-coarse sands, gravels, and cobbles together with small quantities of silt and clay.

The major factors influencing the climate of the Skagit River basin are terrain, proximity of the Pacific Ocean, and the position and intensity of the semi-permanent high and low pressure centers over the north Pacific. The basin lies about 100 miles inland from the moisture supply of the Pacific Ocean. Westerly air currents from the ocean prevail in these latitudes bringing the region considerable moisture, cool summers, and comparatively mild winters. Annual precipitation throughout the basin varies markedly due to elevation and topography. Major storm activity occurs during the winter when the basin is subject to rather frequent ocean storms that include heavy frontal rains associated with cyclonic disturbances generated by the semi-permanent Aleutian Low. During the summer months, the weather is relatively warm and dry due to increased influence of the semi-permanent Hawaiian high-pressure system.

Normal monthly mean temperature data for nine representative stations are presented in Table 2. The mean annual temperature for stations in or near the basin varies from 40.1-degrees Fahrenheit (° F)) at Mount Baker Lodge to 50.7° F at Concrete. Normal monthly temperatures vary in January from 26.9° F at Mount Baker Lodge to 39.1° F at Anacortes, and in August from 56.7° F at Mount Baker Lodge to 64.7° F at Diablo Dam. The temperature extremes recorded in the basin are 109° F at Newhalem and -14° F at Darrington Ranger Station.

Average annual precipitation over the Skagit basin varies by about 150 inches. Mean annual precipitation is 40 inches or less near the mouth of the Skagit River and in the portion of the basin in Canada that lies in topographic rain shadows. Average precipitation of 180 inches or more falls on the higher elevations of the Cascade Range in the southern end of the basin and over the higher slopes of Mount Baker. The annual precipitation over the basin above the town of Mount Vernon averages 92 inches with approximately 75 percent of this amount falling during the 6-month period, October-March. The mean monthly precipitation at stations in or near the basin ranges from 0.96 of an inch in July at Anacortes to 17 inches in December at Mount Baker Lodge. The mean annual precipitation at Baker Lake and Diablo Dam is 102.88 inches and 77.07 inches, respectively. The maximum-recorded precipitation for one month was 41.95 inches at Silverton in January 1953. Storm studies indicate that 5 to 6 inches of rainfall in a 24-hour period have occurred over much of the basin.

Snowfall in the Skagit River basin is dependent upon elevation and proximity to the moisture supply of the ocean. The mean annual snowfall at stations in the basin varies from 6.2 inches at Anacortes to 525.3 inches at Mount Baker Lodge, with a maximum recorded value of 1,140 inches at Mount Baker Lodge during the July 1998 through June 1999 season. Snow surveys have been made within the Skagit River basin since 1943.

Surface wind speeds in the basin are the result of the pressure gradient between high- and low-pressure cells, storm intensity, and topographic effects. Prevailing winds in the lower basin are generally from the southerly quadrant from September through May and from the northerly quadrant from June through August. In the upper valleys above Concrete, the airflow is subject to a topographic funneling effect and is generally up the valley in the winter and down slope in the summer. A diurnal change in direction often occurs in the summer. Occasionally in the winter, cold continental air from eastern Washington or eastern British Columbia will flow through mountain passes creating cold east winds down the valley. In the winter season, storm winds will vary from 20 to 30 miles per hour (mph). During extreme events, winds will exceed 60 mph for short durations with 100 mph gusts occurring over mountain peaks (Reference 27).

The major tributaries of the Skagit River in Skagit County are the Cascade, Sauk, and Baker Rivers, which join the Skagit River at the communities of Marblemount, Rockport, and

Concrete, respectively. Two other major rivers in Skagit County are the Suiattle River, a tributary of the Sauk River, and the Samish River, which originates in the low mountains south of Bellingham in Whatcom County and discharges into Samish Bay at Edison.

2.3 Principal Flood Problems

Flooding problems in Skagit County occur from high-tide levels or from major floods on the Skagit River and its tributaries.

COASTAL FLOODING

The City of Anacortes, the Town of La Conner and unincorporated areas of Skagit County all experience tidal flooding. Tidal flooding can occur when a high astronomical tide (gravitational effects of the sun and moon) is heightened by a large storm surge (rise in water levels due to wind stress and low atmospheric pressure). Wave run-up is a significant factor in areas where the shorelines are not sheltered from local wind effects.

On December 15, 1977, the coastal portions of Skagit County were subjected to an extremely bigb tide which approacbed a 100-year frequency event. The tide was accompanied by strong west winds and low harometric pressure. The following newspaper account from the *Anacortes American* (Anacortes, Washington) describes the December 15, 1977, tidal flood in Skagit County:

> *"The tide spilled water over the dike at Edison, flooding the main road through town. The north end of La Conner was particularly hard hit by the tide. City road crews worked through the morning sandbagging and dumping dirt along First Avenue beside the Swinomish Channel in an attempt to stop the flow of water. The flood water nearly burst the pipes at the La Conner sewage treatment plant."*

RIVERINE FLOODING

Skagit River

Flooding from the Skagit River affects the cities of Burlington, Mount Vernon and Sedro Woolley, the Towns of Hamilton, Lyman, La Conner and the unincorporated areas of Skagit County.

Major floods of the Skagit River and its tributaries are caused by winter rainstorms. 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. Two or more storms in rapid succession, sometimes less than 24 hours apart, are not uncommon. Rain-type floods usually occur in November or December, but may occur as early as October or as late as February. These floods are characterized by sharply rising river flows, high magnitude peaks, and flood durations of several days. Heavy rainfall is often accompanied by snowmelt which increases the runoff. On the mountain slopes, storm precipitation is heavy and almost continuous as a result of combined frontal and orographic effects.

Spring floods also occur on the Skagit River and its tributaries and are due primarily to snowmelt runoff. However, these events are not of sufficient magnitude to be a serious flood threat. Earlier levee construction was to provide protection from spring floods which permitted farmers to plant earlier. These levees were subsequently improved to also provide more winter protection.

The Skagit River represents the major flooding source of the delta area. Flooding occurs from multiple levee failures and from bank and levee overtopping during a 1 percent-annual-chance flood. Downstream of Sedro Woolley, the Skagit River flows through a large delta area that fronts Samish, Padilla, and Skagit Bays. Within this area, the floodplain forms a large alluvial fan with an east-west width of approximately 11 miles and a north-south width of 19 miles.

Five severe floods and the corresponding peak discharges near Sedro Woolley since 1908, when stream gaging in the Skagit River basin began, are listed below in Table 3.

Table 3. Peak Discharges on the Skagit River near Sedro Woolley

Date	Discharge (cfs)
November 1909	220,000
December 1917	195,000
December 1921	210,000
November 1949	140,000[1]
February 1951	150,000[1]

[1]Estimated by the USACE

Prior to the period of record, two floods occurred that far exceeded any of the floods on record. In 1923, J. E. Stewart of the United States Geological Survey (USGS) collected data for and partially completed a report on floods in the Skagit River basin. The data collected and conclusions reached, along with information concerning floods on record through 1957, are published in the USGS Water Supply Paper 1527 (Reference 28). After analysis of all data available, Stewart reached the conclusion that two great floods occurred prior to the arrival of white settlers and that the earlier and greater of these two floods was probably as large or nearly as large as the greatest flood that has occurred here within the last several hundred years. This flood is estimated to have occurred around 1815. Flood discharges as determined by Stewart for a number of historical floods, along with the maximum floods on record, are presented for various stream gage locations, in Table 4.

Table 4. Observed and Historic Floods in Skagit County

Location	Record Flows		Historic Flows	
	Discharge (cfs)	Date	Discharge (cfs)	Date
Cascade River at Marblemount	32,000	Dec. 29, 1917	46,000	1815
Suiattle River above Big Creek near Darrington	29,700	Dec. 4, 1975		
Suiattle River near Mansford	30,700	Nov. 27, 1949		
Sauk River near Sauk	106,000	Oct. 21, 2003		
Skagit River near Concrete	166,000	Oct. 21, 2003	510,000	1815
Skagit River near Sedro-Woolley	220,000	Nov. 30, 1909	400,000	1815
Skagit River Mount Vernon	152,000	Nov. 25, 1990	180,000	1906
Samish River near Burlington	8,440	Jan. 10, 1983		

Another significant flood occurred in December of 1975. Heavy rain began over western Washington State late on November 29 and early on November 30. It did not moderate at most precipitation stations until midnight on November 30. Snow had begun falling over the Cascades late on November 24 and the rate of fall became increasingly heavy as the warmer air arrived. By the afternoon of November 30, the snow had changed to heavy rain. Precipitation continued throughout the next three days, surging between moderate and heavy. The total storm period of late evening on November 29 to early morning on December 4 included three distinct storms following each other in close succession.

Total storm precipitation for the period of November 29 through December 5 at Ross Dam, Upper Baker Reservoir, and Stampede Pass was 12.78, 11.90, and 18.79 inches, respectively. Maximum 24-hour precipitation was 4.10, 3.24, and 6.75 inches, respectively. The maximum recorded discharge at Mount Vernon was 129,200 cfs at 7:30 p.m. on December 4. The river was above zero damage stage for 87 hours and above major damage stage for 67 hours. The 1975 flood was essentially a bankfull flood with little or no freeboard. Only extensive flood fighting enabled the levee system to contain the 1975 flood, which had a recurrence interval of approximately 12 years.

Flooding occurs in the Town of Hamilton when high flows on the Skagit River go over the banks and a levee on Water Street. Floodwaters also enter the town as a result of backup on the Alder Creek slough. Hamilton has experienced flooding problems with resultant damage to property since the 1890s. The following account from the *Spokane Spokesman Review* describes the November 16, 1896, flood in Hamilton:

> *"Probably the town in Skagit County to suffer most by the flood of the Skagit River was Hamilton. The town is a complete wreck. The big brick store building of Baker & Fountaine is a heap of ruins and the grounds are buried under the fallen walls. Everything is in a horrible condition. The streets are washed out, the sidewalks gone and the town is filled with tree stumps and rubbish. Everyone is discouraged and heart-broken and the scene begs description. No lives were lost, although there were several close calls. The water in the lower part of town was up to second stories and some were prisoners upstairs on Saturday noon when they were taken off in boats. The track of the Seattle & Northern Railroad between Woolley and Hamilton has been almost completely destroyed and it will probably be two weeks before the road is in good working condition again. The loss to up-river ranches will be heavy as considerable stock was lost."*

During the flood of December 12-13, 1921, a break in the Skagit River dike upstream from the railway bridge between Mount Vernon and Burlington caused widespread flooding in the Skagit delta, including La Conner. The following account from the *Seattle Post Intelligencer* describes the flood of December 12-13, 1921, in La Conner:

> *"Hundreds of persons on the lowlands of the Skagit River, most of whom had no sleep last night, gazed at daybreak this morning over an expanse (of water) of twenty miles, from La Conner to Chuckanut Mountain. . . . On the La Conner Flats (outside of La Conner) three feet of water was registered (last night while) about 300 people in two suburban districts slept on Auto View Hill, an eminence (sic) in the heart of the city. With them were cattle and horses which had been taken to high ground for safety. . . . Two thousand bags of oats were also destroyed in La Conner when a granary belonging to Mrs. William Bell collapsed and waters of the flood surged about its contents."*

Flooding occurs in Lyman when high flows on the Skagit River go over the banks. Except for low-lying areas in the extreme southwestern and southeastern portions of town, the Skagit River floods do not affect Lyman.

Information about past floods in Lyman is scarce, which indicates that flood hazards are relatively mild. The most recent flood for which information could be obtained occurred on December 18, 1979. This was a relatively minor flood, with a recurrence interval of 13 years for the peak discharge of 136,000 cfs on the Skagit River at Concrete, but it did some damage within the corporate limits of Lyman.

According to the Skagit County Flood Control Officer, floodwaters during the 1979 flood caused bank erosion at the eastern end of Lyman and caused floodwaters to back up at a culvert, then into low-lying areas in that part of town.

Information about past floods in Sedro Woolley is scarce, which suggests that flood hazards are relatively mild. The estimated one-percent-annual-flood discharge will inundate approximately 200 to 300 acres, primarily in the southwestern part of the city. The floodplain contains a county maintenance shop, a sewage treatment plant, a lumber mill, and some residences.

The month of November 1990 included significant floods on November 9th through 11th (the first flood) and November 24th through 25th (the second flood). The floods broke through the Fir Island levee and inundated most of the interior farmland. Both events required extensive flood fighting in the vicinity of Mount Vernon.

A major levee break occurred during the first flood on the east side of Fir Island. The failure occurred about 12 to 14 hours before the peak at Mount Vernon, inundating most of Fir Island with major damage consequences. The Fir Island levee failure caused the Skagit River water level to fall abruptly. The hydraulic relief provided by the Fir Island levee failure was probably instrumental in preventing the failure of other major levees in the vicinity. Emergency repairs to the Fir Island levee were made between the first and second flood. Flood peaks between Concrete and Mount Vernon are normally reduced by attenuation and limited local inflow. This relation was reversed during the second flood due to significant local inflow, saturated soil conditions, and remaining pondage from the first flood.

Flows on the Skagit River reached 160,000 cfs at Concrete and 141,000 cfs at Mount Vernon during the November 28-30, 1995 flood. Concrete was above major damage for one and a half days. Mount Vernon was above major damage for approximately 3 days. As a result of the reservoir regulation and sandbagging efforts, levees at Mount Vernon and Fir Island were able to withstand the flood without failing. This flood set a new crest-stage record at the Concrete gage despite the regulation at Ross and Upper Baker reservoirs. The Concrete gage reached a crest of 41.57 feet. The Mount Vernon gage reached a crest of 37.34 feet, approximately equal to the record stage of 37.37 feet during the November 25, 1990 flood.

The floods of October 2003 started with a smaller peak followed by a larger peak. The first flood peaked at 94,700 cfs at Concrete and 73,500 cfs at Mount Vernon on October 17th and 18th. This exceeded the major damage stage for 6 hours at Concrete but did not get above major damage at Mount Vernon. The second flood was significantly larger and spread more completely across the upper basin and peaked at 166,000 cfs at Concrete and 129,000 cfs at Mount Vernon on October 21st. Concrete was above major damage for 33 hours. Mount Vernon was above major damage for 47 hours. As a result of the reservoir regulation and sandbagging efforts, levees at Mount Vernon and Fir Island were able to withstand the flood without failing.

This flood set a new crest-stage record at the Concrete gage despite the regulation at Ross and Upper Baker Reservoirs. The Concrete gage reached a crest of 42.21 feet, about 0.6 feet greater than the flood of November 1995. The Mount Vernon gage reached a crest of 36.2 feet, which is a foot lower than the peaks seen for November 1995 and November 25, 1990 floods.

Baker River

Flooding from the Baker River mostly affects the Town of Concrete and some of the unincorporated areas of Skagit County.

Heavy rainfall and, often, accompanying snowmelt cause flooding in the Town of Concrete. Flooding occurs in Concrete when high flows on the Skagit River back up into the Baker River and go over banks on both sides of the Lower Baker River. Flooding conditions are aggravated if high flows occur simultaneously on the Baker River. Except for the areas in the vicinity of the mouth of the Baker River, Skagit River floods do not reach the corporate limits of Concrete, which are set back from the river.

Information about past floods in Concrete is scarce, which suggests that flood hazard is relatively mild. The most recent flood for which information could be obtained occurred on July 12 and 13, 1972. This was a relatively minor flood, with a recurrence interval of less than 10 years for the peak discharges of the Baker and Skagit Rivers, 29,400 and 91,900 cfs, respectively, but there was some damage in Concrete.

The following account of this flood was obtained from the Superintendent of the Puget Sound Power and Light (Puget Power) Baker River Project at that time. In anticipation of the flood, the contractor building the present State Highway 20 Bridge over the Baker River was warned that his scaffolding was in jeopardy. The scaffolding was not seriously damaged, but the Baker River floodwaters entered a slough on the right bank, called Little Baker Creek, and damaged the contractor's equipment and a gravel plant downstream from the new bridge. Some of the houses on the right bank were also inundated. This occasionally happens and is always associated with high water on the Skagit River.

Lake Campbell and Erie

Lakes Campbell and Erie are in close proximity to each other and are separated by a short channel from Lake Erie to Lake Campbell. The lakes are near sea level and are the lowest points of runoff from Sugarloaf Mountain and Mount Erie to the north, Ginnett Hill and Rodger Hill to the south. Runoff from rainfall events flows into both lakes causing them to rise simultaneously. The time of concentration between the end of the rainfall and the maximum inflow running off the hills to the lakes is less than 1 day. However, it takes longer than 1 day for Lake Campbell to respond from the maximum runoff from both its own drainage area and the runoff from Lake Erie after it has reached its maximum level and discharge at the outlet. Runoff can also be delayed by debris that may partially block the outlets.

2.4 Flood Protection Measures

The City of Seattle (Seattle City Light) owns and operates a system of three hydroelectric power plants on the Upper Skagit River at the Gorge, Diablo, and Ross Dams. The Ross Reservoir, the only reservoir with available flood storage, has 1,052,300 acre-feet of usable storage between elevations 1,602 and 1,475 feet, of which 120,000 acre-feet are reserved for flood control in compliance with the Federal Energy Regulatory Commission license.

Puget Power operates two hydroelectric power projects on the Baker River: Lower and Upper Baker Dams and Reservoirs located at RM 1.12 and 9.29, respectively. Baker River streamflows have been subject to varying degrees of flood control regulation since completion of the Lower Baker Dam Project in 1927 and the Upper Baker Dam Project in 1959. Flood control storage was increased in 1977 from 16,000 to 74,000 acre-feet at the Upper Baker Project to more effectively regulate Skagit River flows west of Concrete.

During the spring snowmelt period, and to a lesser extent during the winter, the Skagit River flows less than 90,000 cfs at Concrete. Varying degrees of incidental flow regulation occur on the Baker and Skagit Rivers due to hydropower operation of existing reservoirs on both rivers. The amount of water in excess of that required for power generation is either passed through the system or stored for future use. This is especially true during the spring, when the reservoir stage is raised from low winter levels to the normal full pool elevation. Raising the pool in this manner tends to decrease the peak flow downstream.

During the November through March flood season, flood control regulation commences when the Skagit River discharges near Concrete is forecasted to reach or exceed 90,000 cfs. The USACE then directs flood control operations for the Ross and Baker projects. Project releases are selected with reference to formal operating plans which consider flows at Concrete, reservoir pool elevations, and observe and forecast reservoir inflows. Releases from both projects are regulated to minimum levels until the flood peak has passed and the Skagit River has begun to recede at Concrete. Subsequently, project discharge is increased to draft storage from the reservoirs so that flood control storage space is regained.

Storage at the hydropower installations has partially regulated flows on the Skagit River near Hamilton: the Diablo Reservoir since 1930, the Gorge Reservoir since 1960, the Ross Reservoir on the Upper Skagit River since 1940, Lake Shannon since 1926 and Baker Lake on the Baker River since 1959 (Reference 17). Additional flood control storage was established in the Puget Power Upper Baker River Project in 1977.

Although the Upper Baker Dam Project would be regulated during this time to avoid causing another rise in the Skagit River discharge at Concrete, the release from the Upper Baker Reservoir will nearly equal natural peak inflow to the project. In this manner, the net effect of flood control operations on the Baker River is to delay flood runoff, and peak discharges are not significantly reduced except by incidental control for power generation.

Storage data for the major dams within the basin are listed in Table 5.

Table 5. Storage Characteristics of Existing Reservoirs

Reservoir	Flood-Control Storage (Acre-Feet)	Maximum Storage (Acre-Feet)	Maximum Usable Storage (Acre-Feet)	Storage Began
Ross	120,000	1,434,800	1,052,300	March 1940
Diablo	0	90,140	76,220	October 1929
Gorge	0	8,485	6,770	June 1960
Upper Baker (Baker Lake)	74,000	274,213	180,128	July 1959
Lower Baker (Lake Shannon)	0	146,279	116,700	November 1925

Sixteen diking districts maintain approximately 56 miles of levees and 39 miles of sea dikes in the Skagit River delta. Additional levees protect farmland and residences elsewhere in the county, but none of the levees or dikes are adequate to protect against a 1 percent-annual-chance tidal or riverine flood.

The City of Burlington is fronted by a levee that extends approximately one mile upstream of the corporate limits, but the levee will not protect the city from the 1-percent-annual-chance flood on the Skagit River.

Town of Concrete officials in cooperation with the Skagit County Planning Department comply with the NFIP by using building permit regulations and procedures to regulate floodplain development in accordance with the best available floodplain information.

A levee along the Skagit River on Water Street does not provide significant protection to the Town of Hamilton, as it is overtopped by major floods on the Skagit River and outflanked by Skagit River waters backing up into Alder Creek slough.

Town of Hamilton officials in cooperation with the Skagit County Planning Department comply with the NFIP by using building permit regulations and procedures to regulate floodplain development in accordance with the best available floodplain information.

The Town of La Conner has a system of levees in place but there is a 2,200 foot gap in the levee system at the northeast quadrant of the town along the south side of the Drain 15 ditch. This gap exposes the town to flooding from the Skagit River.

Town of Lyman officials, in cooperation with the Skagit County Planning Department, comply with the NFIP by using building permit regulations and procedures to regulate floodplain development in accordance with the best available floodplain information.

The City of Mount Vernon is fronted by levees on both sides of the river, but the levees will not protect the city from the one-percent-annual-chance flood on the Skagit River.

City of Sedro Woolley officials in cooperation with the Skagit River County Planning Department comply with the NFIP by using building permit regulations and procedures to regulate floodplain development in accordance with the best available floodplain information.

The City of Anacortes does not have any physical flood control structures.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood-hazard data required for this study. Flood events of a magnitude that is expected to be equaled or exceeded once on the average during any 10, 50, 100, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10, 50, 100, and 500-year floods, have a 10, 2, 1, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 1-percent-annual-chance flood in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

COASTAL ANALYSES

Elevations for floods of the selected recurrence intervals on Skagit Bay, Swinomish Channel, Similk Bay, Rosario Strait, Burrows Bay, Guemes Channel and Padilla and Samish Bay are shown in Table 6.

Short-term tide records are available at 13 locations in Skagit County, but the nearest long-term record is at Seattle. The Seattle stage frequency curve was used to determine the 10, 2, 1, and 0.2-percent-annual-chance floods discharges tide stages at each of the short term stations by adding the Seattle difference between Mean High Water (MHW) and the selected recurrence interval to the MHW at each short-term station.

A review of tsunami studies and data indicated that tsunamis are not a significant factor in the coastal flooding of Skagit County.

Table 6. Summary of Stillwater Elevations

Flooding Source and Location	Elevation (Feet NAVD88) 10% Annual Chance Flood	2% Annual Chance Flood	1% Annual Chance Flood	0.2% Annual Chance Flood
Burrows Bay				
Langley Point through Burrows Pass to Shannon Point on Rosario Strait	10.3	N/A	10.8	N/A
Fidalgo Bay				
Intersection of Burlington North Railroad and March's Point Road	N/A	N/A	10.8	N/A
Guemes Channel				
Shannon Point to Hat Island Including Fidalgo Bay	10.5	N/A	12.8	N/A
Padilla Bay				
March Point to William Point	10.7	N/A	11.3	N/A
Rosario Strait				
Deception Pass West of State Highway 20 to Langley Point	10.1	N/A	10.6	N/A
Langley Point to Tide Point on Cypress Island	10.4	N/A	10.9	N/A
Samish Bay				
William Point to Northern County Limits, Square Harbor on Guemes Island to Northern County Limits, Yellow Bluff on Bellingham Channel to Northern County Limits and Tide Point on Rosario Street to Northern County Limits	10.6	N/A	11.1	N/A
Similk Bay				
North of Hope Island and Deception Pass West to State Highway 20	11.7	N/A	12.1	N/A

Table 6. Summary of Stillwater Elevations (cont.)

Flooding Source and Location	Elevation (Feet NAVD88) 10% Annual Chance Flood	2% Annual Chance Flood	1% Annual Chance Flood	0.2% Annual Chance Flood
Skagit Bay				
Southern County Limit to Pull and Be Damned Point	11.6	N/A	12.2	N/A
Pull and Be Damned Point to Hope Island	11.5	N/A	12.0	N/A
Swinomish Channel from La Conner to Padilla Bay	11.2	N/A	11.8	N/A
Swinomish Channel				
At La Conner	11.2	N/A	11.8	N/A
At Padilla Bay	10.7	N/A	11.3	N/A

RIVERINE ANALYSES

Skagit River (River Mile 22.4 to 56.61)
The hydrologic analysis was based on flows developed for the Skagit River near Concrete at River Mile 54.1. This location was the focal point for several reasons. There has been a stream gage (U.S. Geological Survey (USGS) gage #12149000) at this location since October 1924 and there are four additional significant historical peaks that were estimated for this location. The stream gage encompasses 88% of the total drainage area of the Skagit River (2,737 square miles). The stream gage is located upstream of any development that could influence the gage other than the dams upstream. It is also in a fairly confined area so there is less likely to be errors associated with the stage-discharge relation at the gage.
The data for the Skagit River near Concrete provides a firm foundation to determine the magnitude and frequency of floods in the Skagit River Basin.

In order to perform a frequency analysis correctly, the watershed conditions need to be consistent during the period of record. This is not the case for the Skagit River near Concrete gage because reservoirs were added throughout the period of record, which have varying affects on reducing floods in the upper basin. Developing a frequency curve that only included flow data with the current flood control storage would restrict the analysis to only using the flow data from 1977 to present. This does not include the larger earlier floods that could greatly influence the upper part of the Concrete frequency curve. When estimating extreme flood events (such as a 1-percent-annual chance flood), it is important to use as much data as possible including historic data unless there is evidence that these data are not indicative of the extended record. The approach used in this analysis was to estimate unregulated flood data for the period of record and then convert these data to regulated conditions using the current operating procedures for all dams in the watershed.

The USGS has published peak discharges for six major historical events that occurred prior to establishment of the stream gage in 1924. The peak discharges for these historical events were determined by J.E. Stewart in the 1920's and published in 1961 in USGS Water Supply Paper 1527 (Reference 28). These data were revised slightly downward in USGS Scientific Investigations Report (SIR) 2007–5159 (Reference 29). The data from the SIR report was used for this analysis. The following table summarizes the historical events for the Skagit River near Concrete gage.

Table 7. Historical Floods for the Skagit River near Concrete

Date of Historical Flood Event	USGS Published Discharge near Concrete (cfs)
1815	510,000
1856	340,000
Nov. 19, 1897	265,000
Nov. 30, 1909	245,000
Dec. 30, 1917	210,000
Dec. 13, 1921	228,000

The latest four flood events (1897, 1909, 1917, and 1921) are all documented in early photographs and newspaper articles and in unpublished reports by J.E. Stewart. The earliest historical flood events (1815, 1856) were also large events, but the relative magnitude of these floods is difficult to determine. The USGS has recently downgraded these flows to estimates due to the fact these estimates are based on single high water marks that were obtained long after these events occurred. There are also concerns that there could have been larger debris jams in the past that accumulated over decades that could have created an artificial dam break flood. This would represent a changed watershed condition that would be hard to account for. Consequently, the 1815 and 1856 floods were not used in the frequency curve calculations.

The effects of regulation to the Skagit River discharge at Concrete were determined by calculating the effects of regulation from the five upstream hydroelectric power dams within the basin. The effects of regulation were determined independently for the three dams located on the mainstem Skagit River (Ross, Diablo, and Gorge) and for the two dams located within the Baker River sub-basin (Upper Baker and Shannon). The effects of regulation from these two sub-basins were then combined to produce an estimate of the overall impact of regulation to the Skagit River discharge at Concrete at a daily time-step. Adjustment of the regulated Skagit River streamflow record at Concrete using the time-series' of estimated effects of upstream regulation resulted in a synthetic time-series of unregulated Skagit River discharges at Concrete.

The historic data contains only instantaneous peak flows so a relationship between peak and 1-day flows is needed to convert these data to 1-day data. Without a similarly sized unregulated basin to draw from, an estimate needs to be made from the existing data. A comparison is made between unregulated 1-day flows with the regulated 1-day flows to determine which floods were minimally affected by regulation. This filtering of the floods was done just for the floods where the unregulated and regulated 1-day flows were within 5 percent of each other (there were 18 winter floods that met this criteria). In addition, there is enough data for the November 1990, November 1995, October 2003, and November 2006 floods to determine the unregulated hourly data for the entire duration of these storms so peak and 1-day unregulated flows can be derived for these events.

The program USACE HEC-FFA was used to perform the flood frequency analysis for the unregulated instantaneous peak flows, 1-day and 3-day flows. This program computes flood frequencies in accordance with the publication titled "Guidelines For Determining Flood Flow Frequencies", Bulletin 17B of the Interagency Advisory Committee on Water Data (Reference 30). The flood frequency is determined by fitting a Pearson Type III distribution to the logarithms of the annual maximum flows. A generalized skew of 0 was used for the analysis of the peak events, –0.04 was used for the 1-day analysis, and –0.12 was used for the 3-day analysis.

Unregulated hypothetical flood hydrographs for the 10-, 2-, 1-, and 0.2 percent annual floods were developed for the Skagit River near Concrete using statistical frequency peak and volume analyses. The hydrograph shapes were roughly based on the October 2003 event. The hydrographs were then balanced to match the necessary 1-day and 3-day volumes. That is, the area of the hydrograph defined by the 1-percent annual peak and 1-day value were shaped so that the 24 hourly discharge values summed and averaged were equal to the 1-percent annual chance 1-day discharge. The same is applied to the flood hydrographs defined by the peak and 3-day values.

The unregulated frequency curve was converted to a regulated frequency curve at Concrete that reflects the influence of flood storage and hydropower operations at Seattle City Light and Puget Sound Energy Reservoirs. There are several steps necessary to develop the existing condition regulated frequency curve at the Skagit River near Concrete gage. These steps include using the available data that reflect the existing flood control operation and then converting the rest of the data set to reflect what the flows would have occurred under the existing flood control storage.

A combination of observed regulated peak flow events and hypothetical computer-simulated data were used to calculate a regulated peak flow frequency curve at Concrete. The computer- simulated data were used to draw the upper end of the frequency curve, while the observed data were used to define the lower end. The regulated frequency curve was defined graphically because the regulated data do not conform to a Pearson Type III frequency distribution as was used for the unregulated analysis.

Skagit River and North and South Forks of Skagit River (Confluence with Samish, Padilla, and Skagit Bays to RM 22.4)

The majority of damages in the Skagit River floodplain are found from Sedro-Woolley to the mouths of the North and South Forks of the Skagit River. It is necessary, therefore, to translate the regulated Skagit River near Concrete flows downstream to this reach. This requires routing these flows using a hydraulic model and adding in the local tributary flows that enter in along this reach.

From Concrete to the mouths of the North and South Forks, the Lower Skagit River Basin has 368 square miles of additional drainage area and local flows from Concrete to Sedro-Woolley and from Nookachamps Creek.

The river below Concrete spreads out into a wider and shallower flood plain. The Skagit River water surface elevation becomes much more sensitive to channel characteristics with and without levees, changing floodplain widths, bridge crossings, and back-water caused by slower velocities as the gradient reduces near the mouth. A hydraulic model is used to calculate the time-varying discharges and stages along the Skagit River instead of a hydrologic model. The hydraulic model takes regulated discharge conditions at Concrete, adds tributary flow along the lower Skagit River and calculates information that is used to construct discharge frequency curves for the reaches downstream of Sedro-Woolley.

Samish River (downstream of Highway I-5)

As a result of the new hydrologic and hydraulic analyses for the Skagit River it was determined that the Skagit River floodplain will no longer influence flooding on the Samish River below Highway I-5. The effective modeling for the Samish River extended upstream from Highway I-5 to its extent in Skagit County. In order to determine the flood hazards for the Samish River below Highway I-5 a search was conducted for previous flood related studies of this portion of the river. In 1995, CH2M Hill completed a study on the Samish River from downstream of Highway I-5 to its confluence with Samish Bay. This report titled "Lower Samish River Basin Comprehensive Flood Hazard Management Plan" was completed in June 1995. The flood discharges on the Samish River were updated using new annual peak data for the period 1997 to 2006. The flood discharges used in the revised HEC-2 model were based on 50 years of data at the gaging station on the Samish River near Burlington, Washington (12201500).

Baker, Cascade, Samish (upstream of Highway I-5), Sauk and Suiattle Rivers

There were no changes to the hydrologic analyses for these streams, thus the effective discharges were maintained.

Lake Campbell and Erie

There is no historical record of lake observations or channel stages in the drainage basin. The nearest observations of weather effects are at Anacortes where there is a daily record of precipitation observations. The National Weather Service gage #530176 at Anacortes had a record extending from 1931 to 1995 at the time of the LOMR.

A time series of the 1-percent-annual chance precipitation was input to a HEC-1 numerical routing model that computed the surface runoff from precipitation. The hypothetically derived 1-percent-annual chance inflow hydrographs were routed through the lakes to compute the 1-percent-annual chance lake water elevations and outflow discharge hydrographs for both lakes.

Peak discharge-drainage area relationships for the Skagit, Cascade, Sauk, Suiattle, Samish and Baker Rivers are shown in Table 8.

Table 8. Summary of Discharges

Flooding Source and Location	Drainage Area (square miles)	Peak Discharge (cfs) 10% Annual Chance Flood	2% Annual Chance Flood	1% Annual Chance Flood	0.2% Annual Chance Flood
Baker River					
At Concrete	297	31,500	44,500	51,000	67,000
Cascade River					
At Marblemount	172	14,300	23,800	28,500	41,700
Samish River					
Near Burlington	87.8	4,670	7,100	8,300	11,500
Sauk River					
Near Sauk	714	52,500	81,000	94,000	129,000
Skagit River					
Downstream of confluence with Baker River (near Concrete)	2,737	116,300	180,260	209,490	316,530
Downstream of Highway 20 (near Sedro-Woolley)	3,015	123,610	183,780	215,270	322,900
Suiattle River					
At Mouth	346	25,800	46,600	58,000	92,000

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report exactly. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

COASTAL ANALYSES

Coastal areas of Skagit County are also subject to tidal flooding. A detailed analysis of tidal flooding was conducted for the coastal areas of Skagit County to determine tidal flooding stages for the 10 and 1-percent-annual-chance flood discharge recurrence intervals and a wave runup factor for use in exposed reaches.

The 1-percent-annual-chance flood discharge Stillwater elevations ($S_{1\%}$) were determined from a tide-frequency curve for the Seattle tide gage by:

$$S_{1\%\ \text{Location "x"}} = (S_{1\%\ \text{Seattle}} - MHW_{\text{Seattle}}) + MHW_{\text{Location "x"}}$$

Previous studies indicate an average wave runup of 1.5 feet for moderately exposed reaches in northern Puget Sound.

The Skagit County shoreline was divided into exposed reaches, or sheltered reaches, and 1.5 feet were added to the 1-percent-annual-chance flood discharge tidal stage for the exposed reaches. In sheltered reaches, no runup factor was added.

RIVERINE ANALYSES

<u>Baker, Cascade, Samish (upstream of Highway I-5), Sauk and Suiattle Rivers</u>
Water-surface elevations of floods for the selected recurrence intervals for the Baker, Cascade, Sauk, Suiattle Rivers and the portion of the Samish River upstream of Highway I-5 were computed by Steady Flow Backwater computations using a computer program (722-K5-G311) developed by the USACE Seattle District, which computes both natural and floodway water surface elevations using the principles of Method II, Engineer Manual 1110-2-1409 (Reference 31).

Backwater models for the rivers were calibrated to the following conditions:

1. Sauk River reach from RM 0.0 to 0.9 – two of the three observed water-surface elevations of the December 4, 1975, flood (65,300 cfs at mouth, a 4.8 percent annual chance recurrence interval) were reproduced within 1.5 feet
2. Sauk River reach from RM 8.9 to 17.8 – 85 percent of the observed water-surface elevations of the December 4, 1975, flood (65,300 cfs at mouth, 21-year recurrence interval) were reproduced within 0.5 foot, and remaining observed water surface elevations were reproduced within 1.2 feet, except for one considered to be unreliable
3. Samish River reach from RM 0.0 to RM 26.0 – 84 percent of the observed water surface elevations of the December 4, 1975, flood (6,090 cfs near Burlington; 1.5

percent-annual-chance recurrence interval) were reproduced within 0.5 foot, and the majority of the remaining 16 percent within 1.1 feet.

Because there were no observed high-water marks for the Suiattle and Cascade Rivers, the models were adjusted with low flow and full-bank flows to obtain a reasonable and smooth water-surface profile. The adjustments were considered satisfactory when no irregularities appeared in water-surface profiles of the 10, 2, 1, and 0.2-percent-annual-chance floods.

The channel cross sections were field surveyed and the overbank cross sections were developed photogrammetrically from aerial photographs (Reference 32). The cross sections were developed in 1977. All bridges were field checked to obtain elevation data and structural geometry.

Geometric data for each bridge and other hydraulic structures were included in the backwater models, the type of flow and the associated head loss at each structure was computed; no additional obstructions were considered. Terrain features, such as roads, railroads, fills, levees, etc., which would have a hydraulic effect, were considered by selecting the cross section locations to include and reflect the controlling effects of such features. No allowances were made in the backwater models for possible sedimentation, aggradation, erosion or channel changes that might have occurred since the cross section surveys or that might occur in the future.

Channel and overbank roughness factors (Manning's "n") were initially based on empirical methods and then adjusted where required during model calibration. Field inspections and photographs aided in the model calibration. Roughness values varied from 0.03 to 0.05 for the channel and from 0.05 to 0.12 for the overbanks.

Starting water surface elevations were established by the development of a starting rating curve using the coincident discharge of the main stem associated with the event being analyzed on the tributary.

Examination of the backwater analyses for the Cascade River showed that flow conditions are very unstable in the upper two-thirds of the study reach, from cross sections H to S. High velocities and numerous supercritical flow conditions were encountered in this reach. To determine "stable" WSELs in this reach, a factor of 0.4 of the velocity head ($V^2/2g$) was added to the computed critical depth (Dc) WSELs. This is based on the condition that flow must be greater than 1.1 Dc to be stable (Reference 33).

Samish River (downstream of Highway I-5)
As a result of the new hydrologic and hydraulic analyses for the Skagit River it was determined that the Skagit River floodplain will no longer influence flooding on the Samish River below Highway I-5. The effective modeling for the Samish River extended upstream from Highway I-5 to its extent in Skagit County. In order to determine the flood hazards for the Samish River below Highway I-5 a search was conducted for previous flood related studies of this portion of the river. In 1995, CH2M Hill completed a study on the Samish River from downstream of Highway I-5 to its confluence with Samish Bay. This report titled "Lower Samish River Basin Comprehensive Flood Hazard Management Plan" was completed in June 1995. The report provided cross section locational information and a hard copy HEC-2 model. The HEC-2 model was used in to determine the approximate 1 percent-annual-chance flood boundary. The cross sections used in the model included those collected by the National Resources Conservation Service in the mid-1980's and additional channel cross

section data collected by CH2M Hill. The Manning's "n" value used for the channel was 0.05 and the values used for the overbanks ranged from 0.05 to 0.1.

Skagit River and North and South Forks of Skagit River (Confluence with Samish, Padilla, and Skagit Bays to RM 22.4)

FLO-2D is used in this study to model the lower Skagit River valley, which is comprised of flows that travel out of stream channels and across the topography of the floodplain. FLO-2D has the capability of modeling both one-dimensional channel flow and two-dimensional overbank flow.

Assembling topographic data is the first task in developing the FLO-2D model for the Skagit River Basin. The entire floodplain for the lower Skagit Valley was aerial surveyed in 1999. This information is used to develop topographic maps of the lower floodplain. A FLO-2D grid of the floodplain has been developed using the information from the aerial flight. The floodplain model uses a grid system to route the overbank flows. For this study a 400-by-400 foot grid is utilized. This grid size is chosen to provide the necessary detail on the floodplain without burdening the model computationally with excess grids.

The average elevation for each grid cell is coded into the model along with information on the location and size of all structures in the floodplain. All features in the floodplain are noted on the new maps including houses, structures, and roads. Elevated roads are input so that the height of the roads could direct flow. The roads are modeled as "levees" that direct flow. Sea dikes are modeled the same way. Structures on the floodplain are reflected in the floodplain model by reducing the flow surface that each grid element can use. Post-processing of the output in conjunction with basin topographic data is performed to generate and define floodplains. The complete model contains 24,295 grids covering 89,238 acres. The grid was used to model the complex overbank flows for the Skagit River.

All of the cross sections from Sedro-Woolley to Skagit Bay were resurveyed in 1999 by Skagit County. Some of these cross sections only included the underwater portions of the cross section so some parts of the 1975 cross sections were used in this reach to provide more detail. FLO-2D does not have capability to model bridges with the same complexity that HEC-RAS does. It uses a rating table that relates the stage upstream of the bridge and the flow making it through the bridge. These bridge rating tables are developed from the relationships observed in the HEC-RAS model for the full range of flows.

The types of boundary conditions in the FLO-2D computer model include inflow and outflow boundary nodes, tailwater conditions, and inflow hydrographs. Inflow boundary nodes are identified in the input file and inflow hydrographs are provided from the HEC-RAS model at the Highway 9 bridge near Sedro-Woolley and for the Upper and the East Fork branches of Nookachamps Creek. Outflow boundary nodes are indicated in the input data along with the general direction of the outflow (among the eight possible directions). The downstream boundary condition on the North and South Forks of the Skagit River is a tidal hydrograph, which has a primary peak at the Mean Higher High Water (8.39 feet NAVD 88), a secondary peak at the Mean High Water (7.49 feet NAVD 88), and a low at the Mean Low Water. The model's flow also exits over the sea dikes on the floodplain into the Swinomish Channel and Padilla Bay, Samish Bay, Skagit Bay, and the Stillaguamish River near Stanwood. Tailwater conditions for the outflow nodes where the land meets open water are based on normal depth, with the slope computed from adjacent node elevations.

The FLO-2D channel model was calibrated to the 2003 flood event and verified with the 1995 flood event. The calibration effort focused on these two events because they best represent the current channel characteristics. The calibration results show that the FLO-2D model is able to appropriately match the observed stage. With limited high water marks available to calibrate the water surface elevation on the floodplain, typical land type roughness values were used to appropriately model the flow in the floodplain. (Reference 27)

Levee Modeling

The 10-, 2-, 1- and 0.2-percent annual chance flood discharges were evaluated to determine whether the levee system could be considered to contain those discharges and meet FEMA freeboard criteria (i.e., at least 3 ft freeboard to top of levee). These computations revealed that, of the discharges considered, only the 10-percent annual chance discharge could be contained below the existing top of the levee and even that flow would not meet FEMA's freeboard criteria.

The methodology for developing the base flood elevations from different levee condition scenarios were derived from Appendix H of the Flood Insurance Study Guidelines and Specifications for Study Contractors. These guidelines state:

"If the subject levee does not meet the requirements stated in 44 CFR 65.10, as verified by the Regional Project Officer, the 100-year flood elevations will be recomputed as if the levee did not exist. None of the subject levee should be recognized as providing 100-year flood protection unless there are portions of the levee system that can meet requirements of 44 CFR 65.10 independent of the remaining levee system. The 100-year flood levels on the unprotected side of the levee will be equal to the 100-year water-surface elevations computed with the levees in place..."

The above procedures for the determination of profiles and floodways can also be applied to the conditions where levees exist on both sides of the stream. If levees exist on both sides of a stream, the evaluation of levee systems must consider the possibility of simultaneous levee failure, failure of only the left side, and failure of only the right side. Simultaneous levee failure should be considered for profile and floodway computations...

For levee systems where an area of land may be totally or partially surrounded by levees or where two or more flooding sources join that have levees on both sides of the stream, the SC should contact the Regional PO before proceeding with any analyses for levee failures. For these complex situations, the flood hazard in the area that would have been protected by the non-failed levee(s) should be based on selection of failure scenarios that yield the highest BFE or flood hazard."

The lower Skagit River valley has levees that encompass all of these conditions. There are levees on both sides of the river from the Burlington Northern Railroad Bridge (River Mile 17.5) to the split at Fir Island into the North Fork and South Fork Skagit Rivers. The North and South Forks also have levees on both sides of the river. Fir Island is completely surrounded by two flooding sources (North Fork Skagit River and South Fork Skagit River). The Big Bend area that encompasses North Mount Vernon also is surrounded by levees on the left bank from the Burlington Northern Railroad Bridge (River Mile 17.5) to the Division Street Bridge (River Mile 12.95). After discussion between the USACE and FEMA, seven levee removal scenarios were deemed necessary to run to appropriately depict the base flood elevation. These scenarios are described in detail in the report titled "Skagit River Basin, Washington, Revised Flood Insurance Study, Hydraulics Study" (Reference 26).

Skagit River (RM 22.4 to RM 56.61)
Water surface elevations of floods for the selected recurrence intervals for the portion of the Skagit River between RM 22.4 and 55.35 were computed using HEC-RAS 4.0 (Reference 34) using the unsteady flow analysis routines.

Cross sectional data from the upstream boundary to the downstream boundary was developed in 1975 for the Flood Insurance Study (FIS) for Skagit County (Reference 1). This data was collected by Seattle District of the USACE's Survey Branch. Floodplain geometry was obtained via aerial photogrammetry, while channel cross sections were field surveyed. All of the 52 cross sections from Concrete to Sedro-Woolley (RM 55.35 to RM 22.4) from the 1984 study are used for this study. In addition, 57 cross sections for the Skagit River from Marblemount to Concrete, 10 cross sections for the Cascade River, 13 cross sections on the Sauk River, and 4 cross sections on the Baker River are used from the 1984 study.

Supplemental bridge data was field surveyed in 1998 by USACE - Seattle District's Survey Section for the State Route 9 (SR-9) crossing at Sedro-Woolley, while bridge data (station, elevation, and distance to adjacent cross sections) for the former Great Northern Railroad Bridge just upstream of the SR-9 crossing was estimated from field measurement, photographs, USGS topographic maps, and profile point data. Bridge low and high chords are modeled along with bridge piers.

Overbank and channel distances between cross sections were assigned by scaling the linear channel and overbank distances between sections on a topographic map. Overbank distances were adjusted according to the presumed flow path. Due to the relatively confined nature of the floodplain from Concrete to Sedro-Woolley and the somewhat steep channel gradient, no HEC-RAS defined off-stream storage areas are used for that reach.

Manning's n values were estimated based on engineering judgment from field assessments of the channel and overbanks of the reach and from interpretation of topographic maps. Manning's n values of 0.035 and 0.04 are typical, while overbank resistance factors of 0.08 to 0.15 are assigned based on judgment dependant primarily on land use, land cover, topography, and historic and expected depth of flooding.

Both upstream and downstream boundary conditions are required for an unsteady flow model. For the Skagit River an upstream hydrograph was developed Marblemount. Additional flow hydrographs were developed for the Cascade River at Marblemount, the Sauk River at Sauk, and the Baker River at Concrete into order to account for these tributary flows to the Skagit River. The stages produced by the lower basin FLO-2D model at the upstream location were used as the downstream boundary condition on the HEC-RAS model since the FLO-2D water surface elevations determined from a 2-dimensional model will be more accurate than 1-dimensional model. This also ensures consistency between the stages upstream and downstream of Sedro-Woolley.

The HEC-RAS model was calibrated to the 2003 flood and verified with the 1995 flood. The calibration results show that the HEC-RAS model is able to appropriately match the observed stage (Reference 26).

Skagit River (RM 56.61 to RM 74)
Water-surface elevations of floods for the selected recurrence intervals for the portion of the Skagit River between RM 55.35 and RM 74 were computed by Steady Flow Backwater

computations using a computer program (722-K5-G311) developed by the USACE Seattle District, which computes both natural and floodway water surface elevations using the principles of Method II, Engineer Manual 1110-2-1409 (Reference 31).

For this reach of the Skagit River the channel cross sections were field surveyed and the overhank cross sections were developed photogrammetrically from aerial photographs (Reference 32). The cross sections were developed in 1977. All bridges were field checked to obtain elevation data and structural geometry.

Geometric data for each bridge and other hydraulic structures were included in the backwater models, the type of flow and the associated head loss at each structure was computed; no additional obstructions were considered. Terrain features, such as roads, railroads, fills, levees, etc., which would have a hydraulic effect, were considered by selecting the cross section locations to include and reflect the controlling effects of such features. No allowances were made in the backwater models for possible sedimentation, aggradation, erosion or channel changes that might have occurred since the cross section surveys or that might occur in the future.

Channel and overbank roughness factors (Manning's "n") were initially based on empirical methods and then adjusted where required during model calibration. Field inspections and photographs aided in the model calibration. Roughness values varied from 0.03 to 0.05 for the channel and from 0.05 to 0.12 for the overbanks.

Lakes Campbell and Erie

The outflow from Lake Erie is controlled by a series of three culverts up to an elevation of about 115 feet above which outflow overtops Campbell Lake Road immediately downstream from the lake. The road overtopping control elevation extends for a length of about 25 feet. The lake elevation versus discharge data was computed beginning at the third culvert and extended upstream to the lake in a step progression where the computed headwater elevation at the downstream culvert was assumed to be the tailwater elevation at the next upstream culvert. Culvert discharge was computed both for an entrance control condition and a full pressure flow condition. All three culverts are very susceptible to blockage by debris and vegetation, therefore, rating relationships were computed both for the most optimistic condition of no blockage and for the most pessimistic condition of 100 percent blockage. Lake routings were accomplished under both conditions to bracket the potential range of the 1 percent annual chance lake elevation. This analysis resulted in a 5.5 foot difference in 1-percent-annual chance lake elevation between the blocked and unblocked conditions. Due to the high potential of blockage of culverts the high elevation was considered to represent the most reasonable expected condition.

The outflow from Lake Campbell is controlled by a series of three culverts and one bridge. The discharge versus elevation rating relationship at the lake outlet was therefore computed using the HEC-RAS steady flow numerical model. The model extended a distance of about 5000 feet from just downstream of the State Highway 20 crossing over the outlet channel to just upstream of the South Campbell Lake road bridge at the lake's outlet. The rating relationship was tested for sensitivity by making various assumptions regarding the blockage of culverts and bridges over the culvert channel.

Seven channel and overbank cross sections were surveyed in August 1998 for use in the numerical model. The model geometry included three culverts and one bridge, all of which were surveyed and measured for appropriate physical data at the same time as the cross sections were surveyed. An approximately 2 foot high concrete weir exists just upstream from the culvert under State Highway 20. This feature was also included in the numerical model. The Manning roughness coefficients used in the model were estimated solely on judgment based on field observations and from the USGS Water Supply Paper 2239 (Reference 35). No high water marks were available with which to check the validity of the estimated roughness coefficients. The starting water surface elevation for the numerical model was assumed to be normal depth.

Water surface profile computations were conducted for two different conditions to determine a range in possible 1-percent-annual chance lake elevations. The first condition was all culverts and bridges remain free of obstructions and the second condition consisted of assuming different blockage scenarios for the different culverts and the bridge. This analysis resulted in a 5.3 foot difference in 1-percent-annual chance lake elevation between the blocked and unblocked conditions. Due to the high potential of blockage of culverts the high elevation was considered to represent the most reasonable expected condition.

Approximate Analyses

Lakes Cavanaugh, McMurray, Beaver, Clear, Big, Cranberry Lake, Heart Lake, Cannery Pond, and Whistle Lake were studied by approximate methods. Flood boundaries for Cranberry Lake, Heart Lake, Cannery Pond, and Whistle Lake were created using topographic and climatic information available in 2003.

River mile stationing shown on drawings and tables in this report was established by interpolating between key landmarks, such as bridges, for which river mile stationing is specified in the river mile index (Reference 36). Because of channel changes since the index was established, the published distances between index stations do not always scale out on the maps. In such cases, the measured flow line distance between cross sections was used in the backwater computation, rather than the stationing distances.

Due to the extreme meandering nature of streams in the study area, stream distances will not always agree between maps and profiles.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM (Exhibit 2).

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD). With the completion of the North American Vertical Datum of 1988 (NAVD), many FIS reports and FIRMs are now prepared using NAVD as the referenced vertical datum.

All Flood elevations shown in this FIS report and on the FIRM are referenced to NAVD88. Structure and ground elevations in the community must, therefore, be referenced to NAVD88.

It is important to note that adjacent communities may be referenced to NGVD29. This may result in differences in Base Flood Elevations (BFEs) across the corporate limits between the communities.

So all elevations currently in NGVD29 can be converted to NAVD88 by adding the conversion factor.

NGVD29 + conversion factor = NAVD88

Baker, Samish, Sauk, Skagit and Suiattle Rivers
The conversion factor between NGVD29 and NAVD88 is 3.8 feet for these rivers.

Cascade River
The conversion factor between NGVD29 and NAVD88 is 3.9 feet for the Cascade River.

For more information on NAVD88, see the FEMA publication entitled *Converting the National Flood Insurance Program to the North American Vertical Datum of 1988* (Reference 37), or contact the Vertical Network Branch, National Geodetic Survey, Coast and Geodetic Survey, National Oceanic and Atmospheric Administration, Rockville, Maryland 20910 (Internet address http://www.ngs.noaa.gov)

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS report provides 1-percent-annual-chance floodplain data, which may include a combination of the following: 10, 2, 1, and 0.2-percent-annual-chance flood elevations; delineations of the 1 and 0.2-percent-annual-chance floodplains; and a 1-percent-annual-chance floodway. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles, Floodway Data tables, and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS report as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community.

Baker, Cascade, Sauk and Suiattle Rivers and the Samish River upstream of Highway I-5
The 1 and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries

were interpolated using topographic maps at a scale of 1:4800, with a contour interval of five feet for the Cascade River, the downstream end of the Suiattle, and the Sauk and Baker Rivers (Reference 38). For the upstream end of the Suiattle River, boundaries were delineated using a topographic map at a scale of 1:24,000, enlarged to 1:12,000, with a contour interval of 40 feet (Reference 39). Boundaries were delineated on topographic maps at scales of 1:24,000 and 1:62,500, both enlarged to 1:4,800, with contour intervals of 20 and 50 feet, respectively, for the Samish River upstream of Highway I-5 (References 40 and 41).

Skagit River (RM 22.4 downstream to split), North and South Forks of Skagit River and the Samish River downstream of Highway I-5

The entire floodplain for the lower Skagit Valley was aerial surveyed in 1999. This information is used to develop topographic maps of the lower floodplain. This information was used to delineate the 1 and 0.2-percent-annual-chance floodplain boundaries. The edges of the flood boundaries were adjusted based on topography provided by Skagit County in 2007 (Reference 42).

Skagit River (RM 22.4 to RM 56.61)

The 1 and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a contour interval of 5 feet (Reference 43).

Skagit River (RM 56.61 to RM 74)

The 1 and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:4,800, with a contour interval of 5 feet (Reference 38).

Lakes Campbell and Erie

For Lakes Campbell and Erie, 1-percent-annual-chance flood discharge approximate floodplain boundaries were determined using historic flood elevations and engineering judgment and were delineated on topographic maps at a scale of 1:24,000, with a contour interval of 20 feet (Reference 44).

Tidal flooding boundaries in areas without levees were derived from inundation maps published in the Coastal Zone Atlas of Washington (Reference 45), which were based on field observations following an extremely high tide in December 1977. The boundaries were delineated on topographic maps at a scale of 1:24,000, with a contour interval of 20 feet (Reference 44). The levees located along the coast are not certified so they were not considered to provide any protection from the 1 percent-annual-chance flood. So in areas along the coast with levees, where the upland areas are subject to flooding from the Skagit River and Skagit, Samish or Padilla Bays, best engineering judgment was used to determine where coastal flooding would dominate and where riverine flooding would dominate.

The 1 and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the Special Flood Hazard Area Zones A, AE, V, and VE, and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1 and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations, but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2).

Approximate 1-percent-annual-chance floodplain boundaries in some portions of the study area were taken directly from the previously effective FIRMs.

4.2 Floodways

Encroachments on floodplains, such as structures and fill, reduce flood-carrying capacity, increase flood heights and velocities, and increase flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. The area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the base flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to one foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (see Table 9, Floodway Data). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the base flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1.

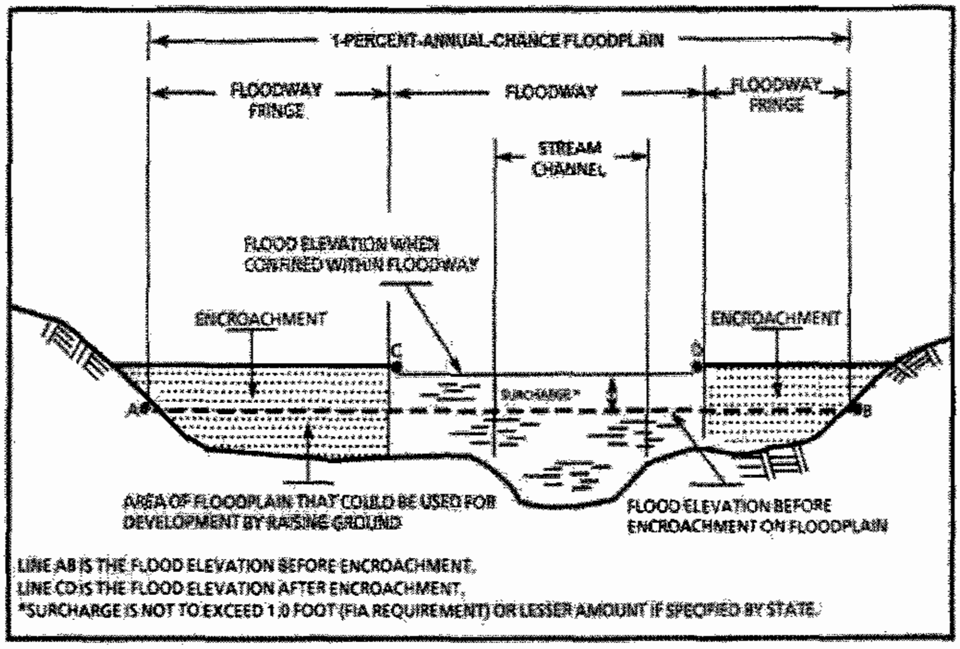

Figure 1. Floodway Schematic

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Baker River								
A	0.24	288	8,092	2.5	190.2	190.2	190.8	0.6
B	0.27	288	8,019	2.5	190.2	190.2	190.8	0.6
C	0.45	326	8,632	2.4	190.2	190.2	190.9	0.7
D	0.50	201	4,622	4.4	194.8	194.8	195.3	0.5
E	0.55	240	4,834	4.2	195.1	195.1	195.7	0.6

[1] Miles above confluence with Skagit River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY
SKAGIT COUNTY, WA
AND INCORPORATED AREAS

FLOODWAY DATA

BAKER RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Cascade River								
A	0.15	1,550	9,582	3.0	320.2	315.7[2]	316.6[2]	0.9
B	0.37	780	2,814	10.1	321.1	321.1	321.4	0.3
C	0.57	1,377	9,667	2.9	328.5	328.5	328.5	0.0
D	0.90	1,757	3,907	7.3	333.5	333.5	333.6	0.1
E	1.33	579	5,607	5.1	342.5	342.5	343.4	0.9
F	1.55	623	4,490	6.3	344.5	344.5	345.0	0.5
G	1.92	620	3,561	8.0	353.8	353.8	353.8	0.0
H	2.34	1,200	2,130	13.3	373.9	373.9	373.9	0.0
I	2.66	1,060	6,751	4.2	387.1	387.1	387.1	0.0
J	2.98	860	2,739	10.4	399.0	399.0	399.0	0.0
K	3.30	390	2,546	11.2	417.9	417.9	417.9	0.0
L	3.61	200	1,589	17.9	435.0	435.0	435.0	0.0
M	3.96	230	1,680	16.9	458.2	458.2	458.2	0.0
N	4.25	580	2,910	9.8	474.3	474.3	474.3	0.0
0	4.55	740	1,273	22.3	496.8	496.8	496.8	0.0
P	5.08	600	1,307	21.7	546.7	546.7	546.7	0.0
Q	5.28	150	1,636	17.4	568.0	568.0	568.0	0.0
R	5.52	130	1,506	18.9	584.8	584.8	584.8	0.0
S	5.78	185	1,244	22.8	613.6	613.6	613.6	0.0

[1] Miles above confluence with Skagit River

[2] Elevations Computed without consideration of backwater from the Skagit River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY
SKAGIT COUNTY, WA
AND INCORPORATED AREAS

FLOODWAY DATA

CASCADE RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Samish River								
A	8.50	687	2,120	4.0	36.3	36.3	36.5	0.2
B	9.20	478	2,535	3.4	39.5	39.5	40.4	0.9
C	9.66	130	1,070	8.0	43.6	43.6	44.0	0.4
D	9.69	411	3,139	2.7	45.0	45.0	45.2	0.2
E	10.30	418	1,302	6.4	49.2	49.2	49.5	0.3
F	10.39	384	1,926	4.3	50.6	50.6	51.1	0.5
G	10.73	643	4,079	2.0	56.5	56.5	57.3	0.8
H	10.85	219	1,281	5.3	57.9	57.9	58.6	0.7
I	11.31	250	1,464	4.7	62.9	62.9	63.6	0.7
J	11.74	365	1,555	4.4	67.3	67.3	67.6	0.3
K	12.24	643	3,163	2.2	71.0	71.0	71.8	0.8
L	12.67	730	2,239	3.0	74.3	74.3	75.2	0.9
M	13.11	100	591	11.5	81.9	81.9	82.2	0.3
N	13.25	485	3,491	2.0	87.1	87.1	87.1	0.0
O	13.48	749	2,205	2.8	89.6	89.6	89.6	0.0
P	13.70	80	788	7.1	93.5	93.5	93.5	0.0
Q	14.10	315	1,261	4.4	96.0	96.0	96.8	0.8
R	14.51	247	1,162	4.8	102.9	102.9	102.9	0.0
S	14.89	100	651	8.6	108.7	108.7	108.7	0.0
T	15.39	87	520	10.8	122.4	122.4	122.5	0.1
U	15.83	222	1,474	3.8	131.0	131.0	131.4	0.4
V	16.20	110	536	10.5	136.7	136.7	136.8	0.1
W	16.56	565	2,033	2.8	146.5	146.5	146.5	0.0
X	17.11	240	1,074	4.5	149.6	149.6	149.7	0.1
Y	17.74	662	1,574	2.9	156.9	156.9	157.2	0.3
Z	17.82	782	1,921	2.3	157.7	157.7	158.1	0.4

[1] Miles above mouth at Samish Bay

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Samish River								
AA	18.11	454	817	5.5	161.3	161.3	161.9	0.6
AB	18.46	755	1,688	2.7	167.3	167.3	168.1	0.8
AC	18.69	759	1,353	3.3	169.0	169.0	169.8	0.8
AD	19.39	524	1,166	3.8	184.2	184.2	184.5	0.3
AE	19.86	650	1,986	2.3	190.2	190.2	190.7	0.5
AF	20.24	702	1,308	3.4	196.0	196.0	196.8	0.8
AG	20.70	360	580	7.7	207.5	207.5	207.8	0.3
AH	21.14	300	946	4.7	217.1	217.1	217.4	0.3
AI	21.47	327	758	5.9	224.4	224.4	224.6	0.2
AJ	21.80	70	469	9.6	237.9	237.9	237.9	0.0
AK	22.00	130	1,071	4.2	245.5	245.5	245.6	0.1
AL	22.41	594	3,827	1.2	246.5	246.5	246.7	0.2
AM	22.76	353	1,591	2.8	247.1	247.1	247.6	0.5
AN	23.05	126	786	5.7	248.9	248.9	249.4	0.5
AO	23.46	110	585	5.6	253.2	253.2	253.5	0.3
AP	23.76	201	1,477	2.1	255.4	255.4	255.4	0.0
AQ	23.91	188	1,192	2.5	255.5	255.5	255.5	0,0
AR	24.35	125	810	3.3	256.1	256.1	256.5	0.4
AS	24.61	193	1,187	2.2	256.5	256.5	257.3	0.8
AT	25.01	104	414	5.5	262.1	262.1	263.1	1.0
AU	25.45	108	437	4.7	267.5	267.5	268.1	0.6
AV	25.72	258	2,159	0.9	269.3	269.3	269.7	0.4
AW	26.00	130	347	5.0	269.9	269.9	270.6	0.7

[1] Miles above mouth at Samish Bay

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA
AND INCORPORATED AREAS

FLOODWAY DATA

SAMISH RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Sauk River								
A	1.03	4,114	38,477	2.4	237.2	237.2	238.2	1.0
B	1.29	3,170	22,129	4.2	238.5	238.5	239.4	0.9
C	1.62	3,574	21,246	4.4	241.0	241.0	242.0	1.0
D	2.35	3,740	24,663	3.8	246.1	246.1	247.1	1.0
E	2.90	1,015	10,309	9.1	251.7	251.7	252.3	0.6
F	3.30	2,408	17,190	5.5	257.7	257.7	257.7	0.0
G	3.79	2,837	20,546	4.6	263.1	263.1	263.9	0.8
H	4.03	2,569	23,699	4.0	267.4	267.4	268.2	0.8
I	4.43	1,531	12,473	7.5	271.4	271.4	272.3	0.9
J	4.73	691	7,637	12.3	278.2	278.2	279.2	1.0
K	4.90	636	9,098	10.3	283.9	283.9	284.3	0.4
L	5.13	566	8,463	11.1	287.8	287.8	288.6	0.8
M	5.43	689	10,868	8.6	293.3	293.3	294.1	0.8
N	5.87	815	13,571	6.9	297.1	297.1	298.1	1.0
O	6.40	643	10,602	8.9	300.1	300.1	300.8	0.7
P	6.83	819	8,243	11.4	303.7	303.7	304.0	0.3
Q	7.00	320	4,801	19.6	306.0	306.0	306.2	0.2
R	7.45	376	7,747	12.1	315.4	315.4	315.4	0.0
S	7.84	415	6,537	14.4	318.2	318.2	318.2	0.0
T	8.23	380	6,153	15.3	322.9	322.9	322.9	0.0
U	8.73	420	5,979	15.7	330.4	330.4	330.4	0.0
V	9.02	646	9,845	9.6	333.9	333.9	333.9	0.0
W	9.73	1,416	11,537	8.2	339.6	339.6	339.8	0.2
X	10.35	2,549	10,254	9.3	347.7	347.7	348.2	0.5
Y	10.65	1,560	7,089	13.4	354.2	354.2	354.9	0.7
Z	11.05	2,460	13,825	6.9	363.4	363.4	363.4	0.0

[1] Miles above confluence with Skagit River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

SAUK RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Sauk River								
AA	11.35	2,245	10,908	8.7	366.7	366.7	366.8	0.1
AB	11.67	1,290	10,628	8.9	372.7	372.7	373.6	0.9
AC	12.01	837	8,806	10.8	377.2	377.2	378.1	0.9
AD	12.30	460	6,814	13.9	380.7	380.7	381.4	0.7
AE	12.81	702	7,236	13.1	387.3	387.3	387.5	0.2
AF	13.30	996	7,546	9.3	396.1	396.1	396.9	0.8
AG	13.66	1,498	14,906	4.7	400.1	400.1	400.9	0.8
AH	14.20	1,560	13,776	5.1	402.6	402.6	403.2	0.6
AI	14.70	1,358	10,330	6.8	406.1	406.1	406.4	0.3
AJ	15.09	1,081	8,156	8.6	410.0	410.0	410.1	0.1
AK	15.40	2,709	19,246	3.6	414.8	414.8	415.1	0.3
AL	16.14	3,382	15,221	4.6	422.4	422.4	422.8	0.4
AM	16.58	3,176	9,920	7.1	429.9	429.9	430.7	0.8

[1] Miles above confluence with Skagit River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

SAUK RIVER

FLOODING SOURCE			FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	MODEL STATION NUMBER	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
						Feet (NAVD)			
Skagit River									
A	22.40	22.40	986	21,430	10.0	52.1	52.1	52.5	0.4
B	23.20	23.14	3,048	49,405	4.4	56.3	56.3	56.7	0.4
C	24.10	23.91	1,842	37,772	5.7	58.9	58.9	59.2	0.3
D	24.70	24.60	4,650	69,994	3.1	60.9	60.9	61.5	0.6
E	25.20	25.17	7,178	135,243	1.6	62.5	62.5	63.0	0.5
F	26.46	26.42	4,870	73,045	3.0	66.0	66.0	66.3	0.3
G	27.04	27.13	5,060	94,517	2.3	67.6	67.6	67.9	0.3
H	27.58	27.62	7,210	115,317	1.9	68.2	68.2	68.5	0.3
I	28.20	28.37	7,420	115,101	1.9	68.8	68.8	69.2	0.4
J	29.10	29.02	9,305	121,516	1.8	69.5	69.5	69.9	0.4
K	29.80	30.02	11,607	146,929	1.5	70.2	70.2	70.6	0.4
L	31.45	31.33	10,450	82,159	2.6	73.1	73.1	73.4	0.3
M	32.10	31.99	7,106	88,426	2.5	76.0	76.0	76.4	0.4
N	33.30	33.06	5,270	70,207	3.1	78.6	78.6	79.0	0.4
O	34.80	34.44	5,470	52,053	4.2	85.5	85.5	85.6	0.1
P	36.70	36.20	7,840	91,281	2.4	93.5	93.5	93.7	0.2
Q	37.34	36.79	7,977	80,470	2.7	95.2	95.2	95.6	0.4
R	39.00	38.63	5,192	58,291	3.7	101.7	101.7	101.9	0.2
S	39.80	39.50	3,536	47,795	4.5	105.4	105.4	105.8	0.4
T	41.10	40.88	2,680	35,507	6.1	110.8	110.8	111.7	0.9
U	42.50	42.10	1,782	26,001	8.3	117.5	117.5	118.1	0.6
V	43.15	42.83	2,228	31,090	6.9	122.4	122.4	122.7	0.3
W	43.90	43.54	930	20,321	10.5	125.8	125.8	125.9	0.1
X	44.50	44.11	2,877	35,185	6.1	129.5	129.5	129.7	0.2
Y	45.20	44.86	4,160	52,643	4.1	134.1	134.1	134.2	0.1
Z	45.90	45.58	2,122	34,144	6.2	137.5	137.5	137.7	0.2

[1] Miles above mouth of South Fork Skagit River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA
AND INCORPORATED AREAS

FLOODWAY DATA

SKAGIT RIVER

FLOODING SOURCE			FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	MODEL STATION NUMBER	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
						Feet (NAVD)			
Skagit River									
AA	46.85	46.55	1,214	20,766	10.2	142.1	142.1	142.1	0.0
AB	47.55	47.09	2,170	31,230	6.8	145.4	145.4	145.8	0.4
AC	48.45	47.93	1,557	26,223	8.1	148.8	148.8	149.0	0.2
AD	49.20	48.61	1,719	26,897	7.9	152.9	152.9	153.0	0.1
AE	49.60	49.05	1,780	26,012	8.1	155.6	155.6	156.3	0.7
AF	50.05	49.57	1,990	36,918	5.7	158.8	158.8	159.8	1.0
AG	50.45	49.99	1,977	34,930	6.1	160.8	160.8	161.7	0.9
AH	51.10	50.72	2,698	53,728	3.9	164.1	164.1	164.9	0.8
AI	51.80	51.31	2,305	42,942	4.9	166.9	166.9	167.4	0.5
AJ	52.40	51.93	914	22,114	9.5	169.4	169.4	169.8	0.4
AK	52.55	52.05	725	18,088	11.6	169.5	169.5	169.9	0.4
AL	52.95	52.48	726	19,362	10.9	174.0	174.0	174.3	0.3
AM	53.30	52.88	711	18,694	11.2	176.3	176.3	176.5	0.2
AN	53.65	53.28	901	24,582	8.5	178.9	178.9	179.2	0.3
AO	54.10	53.68	291	12,071	17.4	179.3	179.3	179.5	0.2
AP	54.65	54.17	682	15,383	13.6	184.1	184.1	184.2	0.1
AQ	55.35	54.78	731	32,480	6.4	187.5	187.5	187.6	0.1
AR	55.75	55.28	1,539	38,950	5.4	190.2	190.2	190.2	0.0
AS	56.70	56.25	702	16,773	11.6	190.2	190.2	190.2	0.0
AT	57.10	56.61	605	18,590	10.5	195.6	195.6	195.6	0.0
AU	*	57.38	1,428	37,006	5.6	198.3	198.3	199.0	0.7
AV	*	57.74	2,285	45,936	4.5	199.0	199.0	199.8	0.8
AW	*	58.16	3,624	66,881	3.1	200.0	200.0	200.9	0.9
AX	*	58.51	3,746	66,543	3.1	200.4	200.4	201.3	0.9
AY	*	59.36	2,243	37,078	5.5	201.8	201.8	202.7	0.9
AZ	*	60.08	2,000	30,589	6.7	204.0	204.0	204.9	0.9

[1] Miles above mouth of South Fork Skagit River

* Data not available

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA
AND INCORPORATED AREAS

FLOODWAY DATA

SKAGIT RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Skagit River								
BA	60.57	966	19,142	10.7	206.1	206.1	206.9	0.8
BB	61.04	1,016	18,456	11.1	209.3	209.3	209.9	0.6
BC	61.48	997	21,521	9.6	212.9	212.9	213.7	0.8
BD	61.79	542	16,087	12.8	214.5	214.5	215.3	0.8
BE	62.26	494	16,215	12.7	217.3	217.3	217.6	0.3
BF	62.69	563	17,774	11.6	219.1	219.1	219.5	0.4
BG	63.14	1,150	29,854	6.9	221.2	221.2	222.0	0.8
BH	63.40	1,112	27,194	7.6	221.6	221.6	222.4	0.1
BI	63.87	727	19,015	10.8	222.7	222.7	223.4	0.7
BJ	64.27	823	21,691	9.5	224.7	224.7	224.9	0.2
BK	64.62	1,289	32,553	6.3	226.6	226.6	227.2	0.6
BL	65.15	1,270	31,320	6.6	228.0	228.0	228.9	0.9
BM	65.58	2,280	42,037	4.9	229.6	229.6	230.6	1.0
BN	65.98	1,663	32,493	6.3	230.9	230.9	231.7	0.8
BO	66.52	3,274	61,564	3.3	232.6	232.6	233.5	0.9
BP	67.09	4,000	43,453	4.7	233.4	233.4	234.2	0.8
BQ	67.60	2,385	34,862	2.8	235.3	235.3	236.3	1.0
BR	67.79	2,069	16,407	5.9	235.7	235.7	236.6	0.9
BS	68.21	3,408	45,243	2.1	237.6	237.6	238.5	0.9
BT	68.67	3,355	34,723	2.8	238.5	238.5	239.3	0.8
BU	69.06	4,948	41,971	2.3	239.7	239.7	240.6	0.9
BV	69.37	5,570	46,067	2.1	240.8	240.8	241.6	0.8
BW	69.89	3,438	27,311	3.5	242.5	242.5	243.4	0.9
BX	70.22	1,753	15,058	6.4	245.1	245.1	245.8	0.7
BY	70.63	3,589	21,937	4.4	249.1	249.1	249.9	0.8
BZ	71.02	1,965	11,382	8.4	252.8	252.8	253.7	0.9

[1] Miles above mouth of South Fork Skagit River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

SKAGIT RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Skagit River								
CA	71.44	2,933	22,077	4.3	257.9	257.9	258.7	0.8
CB	71.85	3,248	24,831	3.9	260.2	260.2	261.1	0.9
CC	72.25	3,742	19,433	4.9	265.4	265.4	266.0	0.6
CD	72.60	3,391	34,661	2.8	270.0	270.0	271.0	1.0
CE	73.09	2,688	23,205	4.1	273.3	273.3	274.0	0.7
CF	73.43	1,634	12,868	7.5	277.9	277.9	278.4	0.5
CG	73.67	2,644	14,205	6.8	281.7	281.7	281.9	0.2
CH	74.03	3,536	19,407	4.9	286.6	286.6	286.9	0.3
CI	74.41	3,367	23,963	4.0	290.4	290.4	290.6	0.2
CJ	74.88	1,970	13,585	7.1	294.1	294.1	294.9	0.8
CK	75.18	1,286	14,461	6.6	297.1	297.1	298.0	0.9
CL	75.62	835	9,217	10.4	300.1	300.1	301.1	1.0
CM	76.00	384	6,843	14.0	303.6	303.6	304.2	0.6
CN	76.45	899	11,584	8.3	308.0	308.0	309.0	1.0
CO	76.88	716	9,837	9.8	310.6	310.6	311.5	0.9
CP	77.24	857	10,867	8.8	313.5	313.5	314.4	0.9
CQ	77.68	1,495	18,647	5.1	318.0	318.0	318.9	0.9
CR	78.20	863	10,117	6.1	320.7	320.7	321.7	1.0
CS	78.65	857	8,358	7.4	323.7	323.7	324.4	0.7
CT	79.12	396	6,201	10.0	326.8	326.8	327.7	0.9
CU	79.40	470	7,329	8.5	329.3	329.3	330.0	0.7
CV	79.72	400	5,972	10.4	331.5	331.5	331.9	0.4
CW	80.02	400	6,136	10.1	334.9	334.9	335.1	0.2
CX	80.34	710	8,823	7.0	338.6	338.6	338.7	0.1
CY	80.59	582	7,763	8.0	340.2	340.2	340.3	0.1
CZ	80.81	301	5,114	12.1	341.7	341.7	341.8	0.1

[1] Miles above mouth of South Fork Skagit River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA
AND INCORPORATED AREAS

FLOODWAY DATA

SKAGIT RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Skagit River								
DA	81.13	407	7,112	8.7	345.1	345.1	345.7	0.6
DB	81.40	382	6,192	10.0	346.8	346.8	347.7	0.9
DC	81.77	412	7,621	8.1	349.9	349.9	350.9	1.0
DD	82.00	422	7,445	8.3	351.4	351.4	352.1	0.7
DE	82.23	671	8,390	7.4	353.2	353.2	353.8	0.6

[1] Miles above mouth of South Fork Skagit River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA

AND INCORPORATED AREAS

FLOODWAY DATA

SKAGIT RIVER

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE-FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					Feet (NAVD)			
Suiattle River								
A	0.10	2,584	25,633	2.3	394.8	394.8	395.3	0.5
B	0.32	1,636	11,960	4.9	396.5	396.5	397.0	0.5
C	0.57	1,400	7,320	8.0	403.9	403.9	404.1	0.2
D	0.77	793	6,213	9.5	413.3	413.3	413.4	0.1
E	1.04	1,140	10,289	5.7	424.5	424.5	425.4	0.9
F	1.40	793	5,064	11.6	433.6	433.6	433.9	0.3
G	1.80	581	5,633	10.4	449.3	449.3	449.4	0.1
H	2.13	1,279	7,262	8.1	460.1	460.1	460.5	0.4
I	2.49	812	6,580	8.9	470.6	470.6	471.5	0.9
J	2.76	570	4,758	12.4	483.5	483.5	483.5	0.0
K	3.08	783	5,967	9.9	494.1	494.1	494.4	0.3
L	3.47	725	6,796	8.7	506.2	506.2	507.0	0.8
M	3.80	270	3,353	17.5	515.4	515.4	515.5	0.1
N	4.19	240	3,684	16.0	529.3	529.3	529.8	0.5
O	4.53	269	3,843	15.3	537.0	537.0	537.6	0.6
P	4.68	251	3,737	15.7	543.7	543.7	544.2	0.5
Q	5.10	212	3,139	18.7	553.6	553.6	554.4	0.8
R	10.60	1,639	14,774	3.6	736.3	736.3	737.2	0.9
S	10.85	734	5,918	8.9	739.0	739.0	739.9	0.9
T	11.15	878	6,849	7.7	745.5	745.5	746.4	0.9
U	11.40	938	5,055	10.4	759.4	759.4	760.1	0.7
V	11.60	766	4,048	13.0	766.2	766.2	767.1	0.9
W	11.80	240	3,726	13.7	784.8	784.8	785.8	1.0
X	11.90	815	6,545	7.8	789.0	789.0	789.9	0.9
Y	12.15	690	3,823	13.3	795.2	795.2	795.3	0.1

[1] Miles above confluence with Sauk River

Table 9

FEDERAL EMERGENCY MANAGEMENT AGENCY
SKAGIT COUNTY, WA
AND INCORPORATED AREAS

FLOODWAY DATA

SUIATTLE RIVER

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains determined in the FIS report by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains determined in the FIS report by detailed methods. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no BFEs are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than one foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than one square mile, and areas protected from the base flood by levees. No BFEs or depths are shown within this zone.

Table 10. Flood Insurance Zones within Each Community

Community	Zone(s)
City of Anacortes	AE, VE, A,
City of Burlington	AE, X
Town of Concrete	A, AE, X
Town of Hamilton	AE, X
Town of La Conner	AE
Town of Lyman	AE, X
City of Mount Vernon	AE, X
Skagit County (unincorporated areas)	AE, VE, A, X
City of Sedro Woolley	AE, X
Sauk-Suiattle Indian Tribe	AE, X
Swinomish Indian Tribal Community	AE, VE, X

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1 and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The countywide FIRM presents flooding information for the entire geographic area of Skagit County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the county identified as flood-prone. This countywide FIRM also includes flood-hazard information presented separately on Flood Boundary and Floodway Maps, where applicable. Historical data relating to the maps prepared for each community are presented in Table 11.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE(S)	FLOOD INSURANCE RATE MAP EFFECTIVE DATE	FLOOD INSURANCE RATE MAP REVISION DATE(S)
Anacortes, City of	October 25, 1974 (Skagit County)	September 13, 1977 April 1, 1980 (Skagit County)	September 17, 2003 (Skagit County)	
Burlington, City of	May 24, 1974	June 4, 1976	January 3, 1985	
Concrete, Town of	May 17, 1974	February 20, 1976	August 2, 1982	
Hamilton, Town of	June 27, 1975	N/A	December 1, 1981	
La Conner, Town of	May 24, 1974	July 23, 1976	December 18, 1984	
Lyman, Town of	November 15, 1974	December 19, 1975	July 19, 1982	
Mount Vernon, City of	May 17, 1974	May 7, 1976	January 3, 1985	
Sauk-Suiattle Indian Tribe	October 25, 1974 (Skagit County)	September 13, 1977 April 1, 1980 (Skagit County)	September 29, 1989	
Sedro-Woolley, City of	May 24, 1974	N/A	July 5, 1982	December 5, 1989
Swinomish Indian Tribal Community	TBD	N/A	TBD	
Upper Skagit Indian Tribe	TBD	N/A	TBD	
Skagit County Unincorporated Areas	October 25, 1974	September 13, 1977 April 1, 1980	January 3, 1985	September 29, 1989

Table 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

SKAGIT COUNTY, WA AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

In June 1972, the USACE, Seattle District, under contract to the Federal Insurance Administration, completed a FIS for the Unincorporated Areas of Skagit County. This study was not formally released by FEMA, but limited distribution was made to State and local officials for interim use in floodplain management. This study supersedes the 1972 FIS.

The USACE, Seattle District, has published several reports and studies on the Skagit River Basin, including: Flood Control and Other Improvements, March 1965; Floodplain Information Studies, July 1966 and April 1967; Sauk River Suggested Hydraulic Floodway, June 1976; Authorization for Additional Flood Control at Upper Baker Project, June 1976; and Skagit River, Washington, General Design Memorandum for Levee Improvements, July 1979. These studies are in agreement with or are superseded by this study.

Additional studies of the Skagit River Basin include the Puget Sound and Adjacent Waters study by the Puget Sound Task Force of the Pacific Northwest River Basins Commission in 1970 and a Comprehensive Land Use Planning Alternatives for the Skagit River Floodplain and Related Uplands report by the Skagit Regional Planning Council in April 1973.

On November 10, 1978, under Public Law 95-625, portions of the Skagit River and its tributaries, the Cascade, Suiattle, and Sauk Rivers, were incorporated into the National Wild and Scenic River System. Studies are underway or have been completed by the United States Forest Service to add detailed boundaries of the river areas and prepare a management plan to protect and enhance those scenic, scientific, geologic, historic, cultural, recreational, and fish and wildlife values for which the river was designated as a component of the National Wild and Scenic River System.

FIS reports have been prepared for the Cities of Anacortes, Burlington, Mount Vernon, and Sedro-Woolley, and the Towns of Concrete, Hamilton, La Conner, and Lyman and the unincorporated areas of Skagit Counties are superseded by this FIS.

This FIS report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA, Mitigation Directorate, Federal Regional Center, 130 228th Street, Southwest, Bothell, Washington 98021-9796.

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10.0 REVISIONS DESCRIPTION

This section has been added to provide information regarding significant revisions made since the original FIS was printed. Future revisions may be made that do not result in the republishing of the FIS. To ensure that any user is aware of all revisions, please contact the appropriate community map repository.

10.1 First Revision (TBD)

This first revision includes the compilation of all single community FIRMs into countywide format using digital processes. This countywide FIRM was compiled with Base mapping provided by Skagit County.

Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the county identified as flood-prone. This countywide FIRM also includes flood-hazard information presented separately on Flood Boundary and Floodway Maps, where applicable. Historical data relating to the maps prepared for each community are presented in Table 11.

New data for this revision include:

The USACE, Seattle District, performed a restudy of the Skagit River in two reaches. The first reach is the lower basin from Skagit Bay upstream to Highway 9 just below the City of Sedro-Woolley. This reach includes the floodplain and base flood elevations but not a floodway. The second reach is from Highway 9 upstream to the Town of Concrete. For this reach both the floodplain and floodway were restudied.

Because the new hydrologic and hydraulic analyses by the USACE for the Skagit River showed that it will no longer influence flooding on the Samish River below Highway I-5, the

Samish River floodplain below Highway I-5 to Samish Bay was revised to approximate Zone A floodplain based on a study of the Samish River completed in 1995 by CH2M Hill.

The specific areas studied by detailed methods, reaches, dates of study, and study contractors are included in Table 1.

Details of the Hydrologic and Hydraulic Analyses are included in Sections 3.1 and 3.2 of this FIS.

The floodplain boundaries for the Skagit River downstream of RM 22.4, the North and South Forks of the Skagit River and the Samish River downstream of Highway I-5 were delineated using topography generated from an aerial survey in 1999. The edges of the Skagit River floodplain were adjusted based on LIDAR topography provided by Skagit County in 2007 (Reference 42). The floodplain boundaries for the Skagit River from RM 22.4 to RM 56.61 were delineated using topography obtained from the USGS (Reference 43).

Additionally, the following Letters of Map Revision have been incorporated during this revision.

- 94-10-061P – resulted in changes to the Skagit River floodway
- 00-10-083P – changed the Zone A floodplain delineation for Lake Erie and changed the flood zone from Zone A to Zone AE with a static BFE for Lake Campbell
- 01-10-105P – resulted in changes to the flooding on Parson Creek