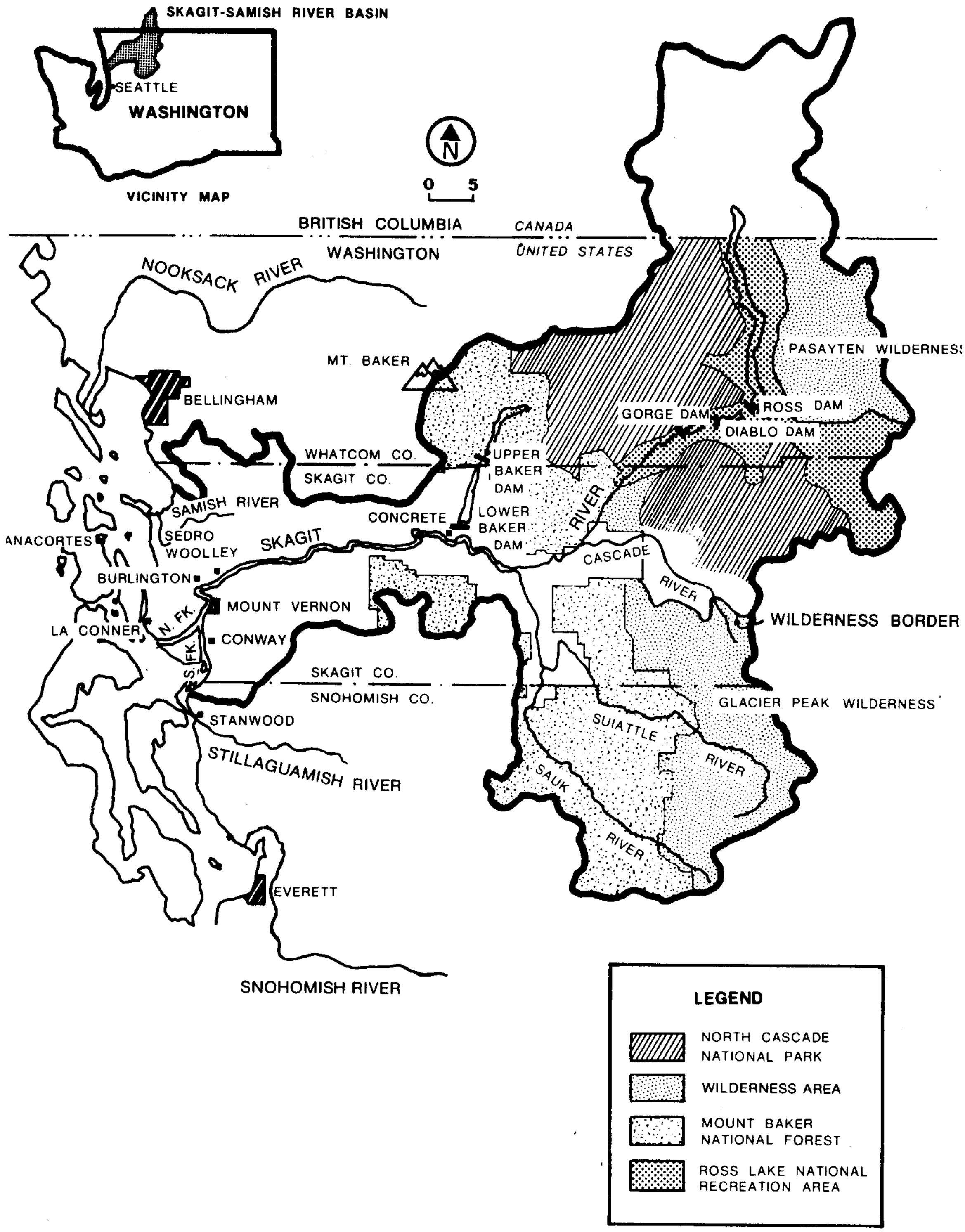
U.S. Army Corps
of Engineers
Seattle District

SKAGIT RIVER FLOOD RISK MANAGEMENT AND ECOSYSTEM RESTORATION FEASIBILITY STUDY
SKAGIT COUNTY, WASHINGTON

Feasibility Scoping Meeting Read-Ahead Report

August 2009



SKAGIT RIVER BASIN

SKAGIT RIVER FLOOD RISK MANAGEMENT AND ECOSYSTEM RESTORATION FEASIBILITY STUDY SKAGIT COUNTY, WASHINGTON

Feasibility Scoping Meeting Read-Ahead Report

US Army Corps of Engineers

Seattle District

August 2009

TABLE OF CONTENTS

Tables

Plates

Appendices

SKAGIT RIVER FLOOD RISK MANAGEMENT AND ECOSYSTEM RESTORATION FEASIBILITY STUDY
SKAGIT COUNTY, WASHINGTON

INTRODUCTION

This Draft Feasibility Report/Feasibility Scoping Meeting Read-Ahead Report documents technical studies and findings of the Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study. This study was undertaken by the Seattle District of the U.S. Army Corps of Engineers and their local partner Skagit County to study flood risks in the Skagit River Basin and to evaluate the feasibility and justification of alternative flood risk management alternatives. The study also evaluates opportunities to pursue ecosystem restoration in conjunction with flood risk management alternatives consistent with the Corps' Environmental Operating Principles and local and agency environmental objectives.

This section of the feasibility report provides an overview of the Congressional Authority for the study, feasibility study background, study area, study sponsorship, and stakeholders.

Feasibility Study Authority

Authority for the feasibility study is derived from Section 209 of the Flood Control Act of 1962 (Public Law 87-874). The authorizing language includes the following:

> *Flood Control Act of 1962, Section 209: "The Secretary of the Army is hereby Authorized and direct to cause surveys for flood control and allied purposed, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: Provided, That after the regular or formal reports made on any survey are submitted to Congress, no supplemental or additional report or estimate shall be made unless authorized by law except that the Secretary of the Army may cause a review of any examination or survey to be made and a report thereon submitted to Congress, if such*

review is required by the national defense or by changed physical or economic conditions: Provided further, That the Government shall not be deemed to have harbor mentioned in his title until the project for the proposed work shall have been adopted by law…" "…Puget Sound, Washington, and adjacent water, including tributaries, in the interest of flood control, navigation, and other water issues and related land resources."

Feasibility Study Background

A Corps reconnaissance study was conducted, resulting in a May 1993 Reconnaissance Report, identifying a Federal interest in conducting a feasibility level study to investigate flood damage reduction measures in the Skagit River basin. The Report identified the following as the alternative with Federal interest:

> Upgrading about 39 miles of existing river levees and providing about 11 new levees, five levee overflow segments, and about a mile of overbank widening (several hundred feet) between Burlington and Mount Vernon.

In July 1997, Skagit County and the Corps executed a Feasibility Cost Sharing Agreement (FCSA) to initiate feasibility studies. The original focus of the feasibility study, as scoped in the June 1997 PMP, was to formulate solutions to severe flooding problems in the study area.

During execution of the early technical studies, the need for ecosystem restoration planning was identified to address new environmental challenges including recent listings of endangered species such as Puget Sound Chinook salmon and bull trout, and the potential listing of Coho salmon and steelhead in the near future. The Corps and Skagit County determined that the incorporation of ecosystem restoration features into the design of a flood damage reduction solution was desirable to developing an acceptable and responsible plan. The addition of ecosystem restoration as a secondary project purpose is consistent with Corps policy to insure compatibility between projects and the environment. The PMP was amended in 2004 to incorporate environmental restoration into the study plan.

Study Area

The Skagit River Basin is located in northwest Washington State and has a total drainage area of 3,115 square miles. The Skagit River originates near the 8,000-foot level of the Cascade Mountains in British Columbia, Canada and flows south and then west to the Skagit delta where it discharges through two distributaries – the North Fork and South Fork – to Skagit Bay. The major cities on the Skagit River delta – Sedro-Woolley, Burlington, Mount Vernon, and LaConner – lie about 60 miles north of Seattle. The entire American portion of the basin is within Washington Congressional District No. 2.

The basin extends about 110 miles in a north-south direction, reaching 28 miles into British Columbia, and approximately 90 miles in an east-west direction between the crest of the Cascade Mountains and Puget Sound. The study area encompasses the Skagit River watershed and the Skagit River floodplain from the Ross Dam reservoir (Ross Lake) to Skagit Bay (**Plate 1**). A detailed map of the lower basin is provided in **Plate 2**.

The Skagit River floodplain contains about 22,000 acres east (upstream) of Sedro-Woolley (RM 22.4) and 74,000 acres west (downstream) of Sedro-Woolley. Principal tributaries of the Skagit River are the Sauk, Baker whidh contributes 59%, and Cascade Rivers. Seattle City Light operates three hydroelectric dams on the Upper Skagit River (Ross, Diablo, and Gorge), and Puget Sound Energy operates two hydroelectric dams on the Baker River (Upper Baker and Lower Baker) (**Plate 6**).

Study Sponsorship

Skagit County is the cost sharing local sponsor for this feasibility study. As the Corps of Engineers partner, the County has provided technical and project management support throughout the study process. Technical areas addressed by the County included real estate and survey support, development of design and costs for the evaluation of measures, public involvement, and development of alternative designs and costs. If a project is implemented, the local sponsor will be responsible for all necessary lands, easements, rights of way, relocations and disposal areas (LERRD) and rights of entry for the project site; as well as project operation and maintenance.

Study Stakeholders

There are many stakeholders associated with this project. The following stakeholders have had direct involvement in the study:

- Washington Department of Ecology
- Washington Department of Fish and Wildlife
- Washington Department of Natural Resources
- Washington Department of Transportation
- Salmon Recovery Funding Board
- Burlington Northern-Santa Fe Railroad
- City of Anacortes
- City of Burlington
- City of Mount Vernon
- City of Sedro Woolley
- Town of Concrete

- Town of Hamilton
- Town of LaConner
- Town of Lyman
- Diking District 1
- Diking District 12
- Diking District 17
- Diking District 20
- Diking District 22
- Diking District 3
- Skagit County Flood Control Zone District
- Skagit River System Cooperative
- State Historic Preservation Office
- Padilla Bay National Estuarine Research Reserve
- National Marine Fisheries Service
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- Burlington Northern-Santa Fe Railroad
- Puget Sound Energy
- Seattle City Light
- The Nature Conservancy
- Skagit Watershed Council

References

U.S. Congress, 1962. Section 209 of the Flood Control Act of 1962 (Public Law 87-874).

MAJOR FEDERAL AND STATE REGULATIONS

Numerous Federal and state regulations apply to floodplain and flood risk management as well as to ecosystem protection and restoration. This section of the feasibility report provides an overview of regulations directly relevant to the feasibility study.

Federal Regulations and Local Implications

National Flood Insurance Program (NFIP)

The U.S. Congress established the National Flood Insurance Program (NFIP) with the passage of the National Flood Insurance Act of 1968. The NFIP, administered by FEMA, is a Federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages. Participation in the NFIP is based on an agreement between communities and the Federal Government. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new construction in floodplains, the Federal Government will make flood insurance available within the community as a financial protection against flood losses. This insurance is designed to provide an insurance alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods (FEMA, 2002).

The official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community is the Flood Insurance Rate Map (FIRM). Skagit County's Flood Insurance Rate Map (FIRM) became effective on January 3, 1985. The FIRM designated unincorporated areas that lie within the 100-year floodplain of the Skagit River. Therefore, Federally subsidized flood insurance is available for local residents. To continue coverage, the County must maintain participation in the NFIP and maintain minimum floodplain management regulations. Skagit County participates in the NFIP Community Rating System (CRS) to obtain credits that further reduce flood insurance premium rate. Mount Vernon, Burlington, Sedro-Woolley and La Conner also take part in the NFIP (Skagit County, 1989).

At the time of writing this report, the County's FIRM was in the process of being updated to reflect current conditions in the study area and current FEMA policies. The Corps feasibility study is based upon Corps regulations and requirements that in some cases differ from those required by FEMA for development of a FIRM and administration of the NFIP.

In September 2008, the National Marine Fisheries Service (NMFS) issued a Section 7 Consultation Final Biological Opinion for Implementation of the National Flood Insurance Program in the State of Washington, Puget Sound Region (NMFS, 2008). Recommended actions from this feasibility study may have an effect on the regulatory floodplains to be identified in the ongoing FIRM update. This could result in need for further future FIRM updates.

Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) of 1972 and subsequent amendments establish a voluntary program under which states can receive financial and technical assistance to formulate a plan for the efficient use of coast zones within their boundaries. The provisions of the CZMA established a planning and regulatory program to manage coastal resources that is initiated at the local level under state guidance with Federal financial assistance. As described in the State Regulations section, shoreline protection is implemented in the State of Washington by the Washington State Shoreline Management Act and in unincorporated Skagit County by the County's Shoreline Management Master Plan (Skagit County, 1989). Any project measures proposed within the shoreline zone will need to be consistent with the State and County plans.

National Environmental Policy Act (NEPA)

The National Environmental Policy Act (NEPA) (42 USC 4321 et seq.) requires Federal agencies to consider the environmental impact of agency and privately sponsored development projects that have a Federal nexus (e.g. Federal funding, projects occurring on Federal land, Federal permits). The NEPA process requires the full disclosure of environmental impacts and consideration of such impacts, along with technical and economic considerations, prior to an agency decision. NEPA requires an EIS for any action with a Federal nexus that would have significant adverse environmental impact. The EIS must thoroughly evaluate any adverse environmental impact of the proposed action and alternatives to that action (Skagit County, 1989). An EIS is under development concurrent with this feasibility study.

As part of the NEPA process, the project involves other federal agencies in the preparation of the EIS as "cooperating agencies". The project has contacted the Environmental Protection Agency, National Marine Fisheries Service, US Fish and Wildlife Service, and other State and tribal agencies to discuss and coordinate project activities. As part of the on-going coordination process with agencies interested in environmental and cultural issues with the Skagit Feasibility Study, the project will establish an Environmental Advisory Committee of interested agencies and groups to assist in development of Environmental Restoration projects and to avoid or minimize important resources during the development of flood reduction projects.

Endangered Species Act

The Endangered Species Act (ESA) provides for the conservation of endangered and threatened species of fish, wildlife, and plants. Threatened species are defined as those that are "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Endangered means that the species is "in danger of becoming extinct throughout all or a portion of its range." When a species is listed as threatened or endangered under the ESA, regulations are adopted to prohibit "take of" (harm to) the species and its habitat. Two salmonid species are listed as threatened in the Puget Sound region. The National Marine Fisheries Services listed chinook salmon (Oncorhynchus tshawytscha) as threatened in May 1999. Regulations to conserve and protect Puget Sound chinook salmon became effective January 8, 2001. The US Fish and Wildlife Service listed bull trout in the Puget Sound region as threatened and put protective regulations in place in December 1999. Both species live in the Skagit River system.

Under Section 7 of the ESA, Federal agencies that issue funding, permits, or approvals to local governments must consult with the Services to ensure that their actions are not harming listed species. A Section 7 consultation is required to gain Services approval of a specific project. Multiple phases of a project (immediate actions and future ones) can be included in a Section 7 approval as long as they are adequately identified and evaluated in the Section 7 biological assessment. Any activity not written into the original Section 7 would require the applicant to go through another Section 7 consultation again to gain approval for that activity. Recommended actions that may affect Chinook salmon or bull trout habitat and require Federal funding, permits, or approvals must go through Section 7 consultation with the appropriate Services (Skagit County, 1989).

2.1.5 Emergency Flood Control Act (PL 84-99)

PL 84-99 provides the authority for the Chief of Engineers, acting for the Secretary of the Army, to undertake activities including disaster preparedness, Advance measures, emergency operations (Flood Response and Post Flood Response), rehabilitation of flood control works threatened or destroyed by flood, protection or repair of federally authorized shore protective works threatened or damaged by coastal storm, and provisions of emergency water due to drought or contaminated source.

All systems considered eligible for PL 84-99 rehabilitation assistance have to be in the Rehabilitation and inspection Program (RIP) prior to the flood event. Acceptable operation and maintenance by the public levee sponsor are verified by levee inspections conducted by USACE on a regular basis. USACE has the responsibility to coordinate levee repair issues with interested Federal, State, and local agencies following natural disaster events where flood control works are damaged.

Levees on the Skagit River system, owned and maintained by Skagit County or a number of Drainage and Diking Districts, have been determined to be eligible for inclusion in the PL 84-99 program. A variety of factors contribute to levee eligibility, including vegetation maintenance. The existing levee system is adequately maintained and is not anticipated to impact the Feasibility Study analysis or impacts resulting form the alternatives investigated.

2.1.6 Fish and Wildlife Coordination Act (FWCA)

The FWCA (16 USC 661 et seq.) requires Federal agencies to consult with US Fish and Wildlife Service, or, in some instances, with National Marine Fisheries Service, and with State fish and wildlife resource agencies before undertaking or approving water projects that control or modify surface water. The purpose of this consultation is to ensure that wildlife concerns receive equal consideration to water resource development projects and are coordinated with the features of these projects. The consultation is intended to promote the conservation of fish and wildlife resources by preventing their loss or damage and to provide for the development and improvement of fish and wildlife resources in connection with water projects. Federal agencies undertaking water projects are required to fully consider recommendations made by US Fish and Wildlife Service, National Marine Fisheries Service, and State fish and wildlife resource agencies in project reports, such as documents prepared to comply with NEPA, and to include measures to reduce impacts on wildlife in project plans.

State Regulations

Flood Hazard Management Statutes

Washington State's Floodplain Management Program (RCW 86.16) integrates local and state regulatory programs in a comprehensive effort to reduce flood damage and protect human health and safety. The state program requires that local flood-prone jurisdictions adopt a flood damage prevention ordinance based on Federal standards contained in the NFIP. Skagit County's Flood Damage Prevention Ordinance (SCC 14.34), is consistent with the requirements of the NFIP, as well as the state Floodplain Management Program. Therefore, Skagit County is eligible for national flood insurance and for matching funds from the state to improve or construct flood management facilities and to develop flood management plans (Skagit County, 1989).

Under the State Requirements for Flood Control by Counties (RCW 86.12), counties are given responsibility for basin plan development, including how land is managed or developed on the floodplain. Plans are to be developed through a participatory process involving cities, towns, or special districts within the basin. Skagit County already has in place a body of policies and regulations that together, satisfy the floodplain development and land use requirements of RCW 86.12. These include a Critical Areas Ordinance (SCC14.24), a Shoreline Management Master Program (SCC14.26), a Flood Damage Prevention Ordinance (SCC14.34), a Land Division Ordinance (SCC 14.18), and a Drainage Ordinance (SCC14.32) (Skagit County, 1989).

Washington State Hydraulic Code

The purpose of the Hydraulic Code (RCW 77.55.100) is to preserve fish and wildlife habitat in and around the waters of the state. The Washington State Department of Fish and Wildlife (WDFW) administers the Hydraulic Code. Hydraulic projects are defined in the Code as work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state. Any work that falls within the definition of a hydraulic project requires a Hydraulic Project Approval (HPA) from WDFW. A cost shared flood control project in the study area would require an HPA.

State Environmental Policy Act (SEPA)

The Washington State Environmental Policy Act (SEPA) (Chapter 43.21C RCW) was passed by the legislature to ensure that environmental values are considered (in addition to technical and economic considerations) in decisions by state and local government officials. SEPA requires preparation of an environmental review (i.e., environmental checklist, environmental assessment, or EIS) documents for any implemented project and adherence to its provisions and guidelines. SEPA is a regulatory tool used by local jurisdictions, such as Skagit County, to control and mitigate activities that are likely to have significant adverse environmental impact (Skagit County, 1989). NEPA compliance documents to be prepared for this study should be sufficient in scope to address all SEPA requirements.

Washington State Shoreline Management Act

The Washington State Shoreline Management Act (SMA) (RCW 90.58) protects public resources, such as water, fish and wildlife and the habitat that supports them, by regulating public and private development in shoreline areas. The SMA applies to all shorelines of the state, including "shorelines" and "shorelines of statewide significance." Shorelines of Statewide Significance are regulated separately from other state shorelines in the SMA and include rivers downstream of where mean annual flow is 1,000 cfs or greater, adjacent lands within 200 feet of the ordinary high water mark, adjacent areas within the floodway, contiguous floodplain areas landward 200 feet from the floodway, and all associated marshes, bogs, and swamps. The provisions of the SMA establish a planning and regulatory program that is initiated at the local level by SCC 14.26. Any project measures proposed within the shoreline zone will need to be consistent with the State Shoreline Management Act.

Revised Code of Washington (RCW) 86.15 Flood Control Zone Districts

RCW 86.15 Flood Control Zone Districts address the organization and funding of county flood control efforts. The eight Sub Flood Control Zone Districts were established by the County based on the provisions of RCW 86.15 (Skagit County, 1989). These eight zones serve areas of the County not served by the Diking and Drainage Districts. Finally, the County has organized a Drainage Utility that provides for drainage and flood control for unincorporated areas not served by Drainage Districts or Sub Flood Control Zone Districts (Skagit County, 2008).

References

FEMA, 2002. National Flood Insurance Program Description, Federal Emergency Management Administration, August 1, 2002.

NMFS, 2008. Endangered Species Act – Section 7 Consultation Final Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Implementation of the National Flood Insurance Program in the State of Washington Phase One Document – Puget Sound Region. Consultation conducted by National Marine Fisheries Service Northwest Region. https://pcts.nmfs.noaa.gov/pcts/.

Skagit County, State of Washington (1989). *Skagit County Comprehensive Flood Control Management Plan.* Skagit County, WA. Consulting Engineers: Brown and Caldwell.

Skagit County, State of Washington (2008). Surface Water Management: Drainage Utility. Retrieved January 26, 2009, from Skagit County Public Works Web site: http://www.skagitcounty.net/Common/Asp/Default.asp?d=PublicWorksSurfaceWaterManagement&c=General&p=drainageutility.htm

PRIOR STUDIES, REPORTS, AND WATER PROJECTS

This chapter provides a summary of Corps studies and project authorizations, Skagit County Reports, water resource projects in the area, and local flood control planning and flood fighting framework.

Prior Corps Studies and Project Authorizations

Prior Corps study reports date back to the late 1800's. A listing of major reports is provided in Table 3-1, and the following paragraphs summarize some of the key studies.

Skagit River Avon Bypass Flood Control Project

This Corps project included a diversion channel from near Burlington to Padilla Bay, a gated control structure near the intake, a control weir near the outlet and a levee on the right bank upstream from the bypass. This project was first authorized by the Flood Control Act of 1936, but was classified inactive in 1952 because local requirements could not be met. Site selection studies were completed again in the 1960s, and construction authorized. However, the sponsor was not able to meet local participation requirements. The project was deauthorized Jan. 1, 1990, under provisions of Public Law 99-662.

Skagit River Levee and Channel Improvements Flood Control Project

This Corps project was authorized by Congress in 1966. The project would have involved levee raising and strengthening and channel modifications from the Burlington Northern railroad bridge in Mount Vernon to the mouth of the Skagit River. Advance engineering and design studies were started in 1977 and a general design memorandum was completed in 1979. The report recommended a change in the authorized project to provide 50-year flood protection to rural lands downstream of Mount Vernon and 100-year flood protection for the urban areas from Mount Vernon to Sedro Wooley, with standard project flood protection for downtown Mount Vernon. Nonstructural measures were included to reduce flood damages in the Nookachamps Valley and the Sterling area. In November 1979, Skagit County voters rejected a proposition to provide funding for the local share of costs. Skagit County withdrew as the sponsor, and, consequently, further effort on this project was terminated. The project was deauthorized in July 1995 under provisions of Public Law 99-662.

West Mount Vernon Section 205 (Small Flood Control) Study

In May 1992, Skagit County requested Corps assistance under authority of Section 205 of the 1948 Flood Control Act with the particularly acute flood problems of West Mount Vernon. Current flood fighting efforts usually cut off access across the State Highway bridge between downtown Mount Vernon to West Mount Vernon, creating a potentially dangerous situation for residents of West Mount Vernon. The Reconnaissance Study was completed in 1994 and determined that levee improvements along with non-structural measures and bridge modifications were worthy of further study. A plan was developed to fund the local share of study costs by Skagit County, the city of Mount Vernon, and the Washington State Department of Transportation. However, in June 1995 Skagit County declined to proceed with feasibility studies at that time and further work was deferred. the City did purchase and remove several homes located along the most flood prone section of the river bank and enlarged the bridge span to increase conveyance on the right bank.

Hamilton Section 205 (Small Flood Control Study)

A Section 205 Flood Control Study was completed for the City of Hamilton, WA. The study found no Federal interest in the project due to lack of economic justification.

Skagit Flood Risk Management and Ecosystem Restoration Study

This study is being conducted under the authority of Section 209 of the Flood Control Act of 1962 (PL87-874). Skagit County is the local sponsor. In 1993, a Reconnaissance Study of reducing flood damages in the Lower Skagit River Basin was completed which determined that levee improvements with overtopping segments and non-structural measures were worthy of further investigation during feasibility studies. In 1994, Skagit County asked that further work be deferred. Following the November 1995 flood, Skagit County requested the study be resumed. In July 1997, Skagit County and the Corps executed a Feasibility Cost Sharing Agreement (FCSA) and initiated the current feasibility study.

Table 3-1: Prior Corps Reports, Skagit River Basin

• 1897 – Survey of Skagit River from its Mouth to Sedro, WA. Survey (S) by Capt. Harry Taylor, Corps of Engineers {published as House Document #204, 55th Congress,2nd Session}
• 1914 – Skagit River, WA, PE by Major J. B. Cavanaugh, Corps of Engineers, S by same {published as House Document #935, 63rd Congress, 2nd Session}
• 1925 - Skagit River, WA, PE by Col. W.J. Barden, Corps of Engineers {published as House Document #125, 69th Congress, 1st Session}
• 1928 - Skagit River, WA, PE by Major Jno. S. Butler, Corps of Engineers {published as House Document #311, 70th Congress, 1st Session}
• 1932 - Skagit River, WA, A General Plan for the Purposes of Navigation and Efficient Development of its Water Power, the Control of Floods, and the Needs of Irrigation, by Lt. Col. C.L. Sturtevant, Corps of Engineers {published as House Document #187, 73rd Congress, 2nd Session}
• 1937 - Skagit River and Tributaries, WA. PE by Lt. Col. H.J. Wild, Corps of Engineers
• 1940 - Skagit River and Tributaries, WA. Survey by Col. B.C. Dunn, Corps of Engineers
• 1964 - Avon Bypass, Skagit River, WA. Reactivation Report (RR), with Supplement (SUP) to NPS Reactivation Report of November 1963, Corps of Engineers
• 1965 – Skagit River Basin, WA. Flood Control and Other Improvements by Colonel C.C. Holbrook, Corps of Engineers
• 1966 – Supplement to Review Report on Flood Control and Other Improvements on Skagit River, WA, Corps of Engineers
• 1966 - Avon Bypass, Skagit River, WA, Design Memorandum No. 1, Site Selection, Corps of Engineers
• 1966 - Skagit River, WA., Interim Review Report (IRR)by Colonel C.C. Holbrook, Corps of Engineers {published as House Document #483, 89th Congress, 2nd Session}
• 1979 – Draft Environmental Impact Statement, Skagit River Levee Improvement Project, Corps of Engineers
• 1993 - Draft Reconnaissance Report, Skagit River, WA, Flood Damage Reduction Study, Draft #2, Corps of Engineers {Final Draft}

Skagit County Reports

In 1989 Skagit County developed the Skagit County Comprehensive Flood Control Management Plan which was approved by the Washington State Department of Ecology (DOE) in order to satisfy the requirements of RCW 86.26 and WAC 173-145-040. This planning document served as a guide for Skagit County flood control activities for the last 14 years. The County is currently in the process of updating the CFCMP to include recent planning efforts for Skagit River Flood Control to incorporate new data developed as part of the current Corps/County Flood Damage Reduction and Ecosystem Restoration Feasibility Study.

Federal Water Resources Projects in Study Area

The Corps has constructed several navigation and ecosystem restoration projects in the Skagit River Basin and has authority for flood control operations at Puget Sound Energy’s Baker River hydroelectric project. A summary of these projects is provided below.

Skagit River Navigation Project

In 1911, the Corps constructed a training dike 10,450 feet long at the entrance of the Skagit River's South Fork, a mattress sill at the head of Old River, and four dikes to close subsidiary channels. The mattress sill was removed in l970 as it had become a hazard to navigation. Uncompleted portions of the project (increasing the depth at Skagit City bar by dredging and training dikes and extending the training dike to 16,000 feet) were deauthorized Oct. 3, 1978.

Deepwater Slough Section 1135 Ecosystem Restoration Project

This project is located on the south fork of the Skagit River between Freshwater and Steamboat Sloughs (referred to as Deepwater Slough) and the adjacent Milltown Island, south of the town of Conway entering the east side of the Skagit Bay estuary, in Skagit County, WA. The second and distinct portion of this area is Milltown Island on the east side of the Milltown area, bounded by Steamboat Slough to the west and Tom Moore Slough to the east. This project restored river and tidal influence to 204 acres of the Washington Department of Fish and Wildlife Skagit Wildlife Area that has been affected by the Corps' Skagit River Navigation Project. The existing dike structures in the Deepwater Slough area and Milltown Island have created a system of disconnected habitats. With the dikes in place, there was no hydraulic connectivity between these habitats and the river and estuarine environment to support nutrient transfer. These dikes also had limited the creation of subsidiary and blind channels. Construction was completed in 2001 which included approximately 8,300 linear feet of new dikes and augmentation and rehabilitation of 10,000 linear feet of existing dikes. A bridge crossing for Deepwater Slough was installed and the environment was enhanced with native species plantings and large woody debris placement. The dike at Milltown Island was breached through the use of explosives in three locations to restore tidal and riverine flows. By restoring the natural hydrologic processes that form habitat a variety of new habitats have been created and enhanced. These habitats include main tidal channels, subsidiary channels, blind channels, and estuarine emergent marsh to benefit both waterfowl and juvenile salmon.

Swinomish Navigation Channel

This completed navigation project separates Fidalgo Island from the Skagit County mainland. Dredging and diking of this inland passage were completed in l937. The 11-mile-long channel connects Padilla Bay on the north with Saratoga Passage on the south. The channel is used extensively by tugboats with log tows, recreational craft, and freight vessels. In 1965, the Corps of Engineers completed removal of projecting rock points obstructing navigation near the south end of the channel. The south jetty, west of Goat Island, was rehabilitated in 1973.

La Conner Streambank Erosion Control Project

Additional bank erosion control measures to prevent damage to structures in the La Conner Historical District were authorized by Section 603, Public Law 99-662. A Decision Document was prepared which showed that a shore protection project along 1,500 feet of the La Conner waterfront would be economically feasible and there would be a Federal interest in such a project. Preconstruction engineering and design began in fiscal year 1991 with preparation of the Design Memorandum and Environmental Assessment. These were completed in March 1994. Following completion of Plans and Specifications and acquisition of the necessary permits and needed real estate interests, construction began in September 1995 and was substantially finished by December with mitigation planting being completed in April 1996.

Skagit River - Upper Baker Lake Flood Control Project

The planning study, carried out under the Puget Sound and Adjacent Waters Comprehensive Study authority, was completed in 1975. It recommended additional flood control storage be provided by a change in operation of Upper Baker Dam, owned by Puget Sound Power and Light Company (PSP&L) now known as Puget Sound Energy (PSE). In 1977, Congress authorized the project and storage was available during the winter of 1977-78. As part of Puget Sound Energy's (PSE) operating license of Baker Dam (amended by congress in 1976), PSE must maintain 16,000 acre feet of reservoir storage as replacement of valley storage eliminated by the development of the project. In addition, the license requires an additional 58,000 acre-feet of Federally authorized flood control volume up to a total of 100,000 AF of storage as requested by the Corps district engineer. The evaluation of additional storage under FERC's relicensing of the PSE hydroelectric project was deferred to the Skagit GI as part of a settlement agreement signed by interested parties to the 2006 FERC relicensing process.

The flood control operation is governed by an agreement between the Corps and PSE, documented in the Water Control Manual for the dam. Under the agreement (and consistent with Article 32 of the license), PSE operates the Upper Baker project to provide 16,000 acre-feet of flood control storage space between November 1 and November 15. This requires that Baker Lake be drawn down to elevation 724.5 feet msl (NAVD 88) (3.2 feet below full pool) by November 1 of each year. Additionally, the agreement specifies that under normal operating conditions the full 74,000 acre-feet of flood control storage be provided from November 15 to March 1; this requires that Baker Lake be drawn down to elevation 711.56 feel msl (NAVD 88) by November 15 of each year (16.2 feet below full pool).

During flood events when natural flow in the Skagit River is forecasted to exceed 90,000 cfs at Concrete, the Corps assumes responsibility for Baker Lake flood control regulation and coordinates the Upper Baker Project operation with Seattle City Light's Ross Lake reservoir on the Upper Skagit River to reduce the flood peak in the Lower Skagit River valley. Collectively, Baker Lake and Ross Lake reservoirs control runoff from about 40 percent of the Skagit River basin. The flood control storage space is used to retain water during floods that can be later released as the unregulated flood flows in the Skagit River recede (PSE, 2004). Additional information on PSE's Baker River Hydroelectric Project is provided in the following section.

Non Federal Water Resources Projects in Study Area

Numerous non-Federal water resources projects have been constructed and are in operation in the Skagit River Basin. These projects include dams in the upper basin and a series of levees extending throughout basin.

Puget Sound Energy Baker River Hydroelectric Project

Puget Sound Energy owns and operates a hydroelectric project on Baker River, a tributary of the Skagit. The project consists of two power-generating dams and two reservoirs. These dams impound the two reservoirs Lake Shannon and Baker Lake, respectively. Both reservoirs are fed primarily by melting snow from the Cascade Mountains (PSE, 2008) (**Plate 6**).

The project begins about a mile upstream from Baker River's confluence with the Skagit at Lower Baker Dam, inside the town of Concrete. Lower Baker Dam is the older component of the project, completed in 1925. It is a 285-foot-tall, 550-foot-long concrete gravity arch structure. Lower Baker Dam can generate up to 85 megawatts of power. The dam's reservoir, Lake Shannon, controls a total of 299 square miles of watershed via 84 square miles of local drainage and 215 square miles of drainage above Upper Baker Dam (Puget Sound Energy, 2008).

Upper Baker Dam was completed in 1959. A concrete gravity dam, it measures 312 feet high and 1200 feet long. At maximum capacity, Upper Baker can produce 105 megawatts of power (PSE, 2008). The dam's reservoir, Baker Lake, controls 215 square miles of watershed (Puget Sound Energy, 2008).

Together, the two dams can serve the peak power demand of about 190,000 households. On average, they can serve the total power demand of about 60,000 households (PSE, 2008). The Baker Dams are used for flood storage during the November through March flood season. Combined with storage capacity at Seattle City Light's hydropower projects on the Skagit River, the dams in the Skagit Basin have the capability to control approximately 40% of the Skagit watershed (Skagit County, 2003).

Seattle City Light Skagit Hydroelectric Project

Seattle City light also owns and operates a large hydroelectric project in the Skagit Basin. Located far upstream on the Skagit River, the project begins just upstream of the town of Newhalem and extends upstream about 30 miles, turning northward out of Skagit County and extending into Canada. The project consists of three reservoirs and three dams (**Plate 6**). High in the North Cascades, the project is fed primarily by snowmelt.

At the downstream end of the project, in Newhalem, is the Gorge Dam Powerhouse. The dam is located 2 miles upstream. To connect the facilities, a tunnel was constructed to convey water from the dam to the powerhouse. The dam, tunnel, powerhouse were completed in 1924. Sitting behind the dam, Gorge Lake extends upstream to the second dam, Diablo Dam. Diablo Dam was completed, and Diablo reservoir filled, in 1930. Construction slowed by the Great Depression, the Diablo powerhouse did not come online until 1936. Diablo reservoir continues upstream until the third dam, Ross Dam. Ross Dam impounds the very large Ross Lake, which turns northward, out of Skagit County, and across Whatcom County. The watershed extends into Canada, as well. Ross Dam and powerhouse came online in 1951 (SCL, 2008).

The three dams provide about 39% of Seattle City Light's power generation capability. Gorge Dam has a maximum capacity of 199.2 megawatts. Diablo Dam can output 159.3 megawatts. Ross Dam can generate up to 352.6 megawatts (SCL, 2008). In addition to power generation, Ross Dam Reservoir on the Skagit River controls the drainage from 978 square miles of watershed. Ross Dam is used for flood storage during the November through March flood season. Combined with storage capacity at PSE's Baker Project, the dams in the Skagit Basin have the capability to control approximately 40% of the Skagit watershed (Skagit County, 2003).

Non Federal Flood Control Planning

Since the early 1980's, local flood control planning for the Skagit River has been coordinated by the Skagit River Flood Control Committee (FCC). This committee is composed of representatives from Diking and Drainage Districts, planners from various municipalities and citizens from special affected areas. The function of the FCC is to provide for coordination of efforts in floodfighting, flood control structural improvements and funding efforts. Areas not covered by the Diking and Drainage Districts are served by one of the ten Sub Flood Control Zones (SFCZ) or the Skagit County Drainage Utility (DU) (Skagit County, 2003).

Diking and Drainage Districts

The State of Washington authorized the formation of Diking and Drainage Districts. These districts are given responsibility over dikes and drainage systems, may petition the County for funding and assistance, and can assess those within the district that are receiving benefits. Local control of diking and drainage is maintained, yet proper permit application and review procedures are required to prevent piecemeal flood control projects that might be inconsistent with resource management regulatory programs (Skagit County, 1989). For Diking and Drainage District boundaries, see **Plates 3 and 4**.

Skagit County's active Diking Districts are responsible for building and maintaining levees along both banks of the Skagit River to protect urban and agricultural land. These levees are estimated to provide 25-50 year flood protection. The Districts have built and/or maintain levees along both sides of Skagit River from the Burlington Northern Railroad Bridge to the split at Fir Island into the North Fork and South Fork Skagit Rivers. Levees on the right bank begin upstream near Burlington City limits and levees on the left bank begin at the Burlington Northern Railroad Bridge (**Plate 5**). Fir Island, the delta between North and South Forks of Skagit River, is surrounded by levees and sea dikes along Skagit Bay (FEMA 2007).

The Diking Districts are also active in floodfighting. In 2007 the City of Mount Vernon and Dike District 3 teamed to purchase a portable floodwall. The wall comes in easily stored 4-foot by 8-foot panels that are set into a cement track. With the track already complete, Mount Vernon can have a wall set up from

Division Street Bridge to Kincaid Street in just two to three hours with a crew of 28 people, a significant improvement over the 12 hours it would typically take to construct a wall of sandbags using approximately 2,000 volunteers (NBM 2007).

Sub Flood Control Zones and the Drainage Utility

Various special taxing districts have been established to deal with flooding problems in the unincorporated areas of the County. Responsibility for the activities of these Sub Flood Control Zones and the Drainage Utility lies with the County Engineer/Public Works Director. Through the operation of these organizations numerous small scale flood control and drainage facilities have been constructed and maintained (Skagit County, 2003).

References

FEMA 2007. Skagit County, WA FIS; Lower Skagit River hydraulic modeling of levee systems, February 28, 2007 Federal Insurance and Mitigation Division, FEMA Region X.

NBM 2007. Northwest Business Monthly, Volume 32, Issue 9, September 2007. Mount Vernon River Rage.

PSE (Puget Sound Energy), and MWH Engineering (2004, March).Baker River Hydroelectric Project: Upper Baker Development FERC Project No. 2150. *Supporting Technical Information*. *Draft Report*, 28,29.

(PSE) Puget Sound Energy, (2008). Baker River Hydroelectric Project: Fact Sheet. Retrieved January 26, 2009, from Puget Sound Energy: Energy and Environment: Baker River Hydroelectic Project Web site: http://www.pse.com/SiteCollectionDocuments/mediaKit/045_Baker_Hydro.pdf

Puget Sound Energy. 2008. Baker River Project Part 12 Probable Maximum Flood Study: FERC Project No. 2150: Final Report. Prepared by Tetra Tech, Inc.

(SCL) Seattle City Light, (2008). Seattle City Light Fingertip Facts: Your Electric Utility's Customer Information Guide. Retrieved January 26, 2009, from City of Seattle (Seattle.gov) Web site: http://www.seattle.gov/light/AboutUs/CustomerGuide/docs/fingertipfacts_2008.pdf

Skagit County, State of Washington (1989). *Skagit County Comprehensive Flood Control Management Plan.* Skagit County, WA. Consulting Engineers: Brown and Caldwell.

FEASIBILITY STUDY PURPOSE, SCOPE, AND STATUS

Purpose

The feasibility study has two primary purposes: to investigate, formulate and recommend a comprehensive flood hazard management plan for the Skagit River floodplain that will reduce flood hazards and damages in the project area; and to investigate formulate, and recommend measures to restore ecosystem functions and processes to benefit fish and wildlife in the project area. The feasibility phase of project development involves technical studies to assess the effectiveness, efficiency, acceptability, and completeness of a range of alternative solutions to serious flooding problems, potential early action flood damage reduction measures, and ecosystem restoration opportunities in the study area. The implicit intent is that the recommended plan will have broad federal and non-federal support, will provide critically needed flood damage reduction benefits at an affordable cost in a reasonable time frame, will provide cost-effective ecosystem restoration benefits in the project area, and will subsequently be authorized and implemented.

Scope

The study area encompasses the Skagit River watershed and associated floodplain from the Ross Dam reservoir (Ross Lake) to Skagit Bay (**Plate 1**). A detailed map of the lower basin is provided in **Plate 2**. The technical scope of study involves assessment of the effectiveness, efficiency, acceptability, and completeness of a range of alternative solutions to flooding problems, identify potential early action flood risk management measures, develop a mitigation plan, and identify ecosystem restoration opportunities in combination with the flood risk management measures. Flood risk management measures will be evaluated for sustainability, residual flooding risk, conformance with Corps Environmental Operating Principles, and environmental, cultural, and socio-economic impacts.

Areas of Technical Analysis

Areas of technical analysis conducted as for this feasibility study have included public involvement, environmental and cultural studies, geomorphology and sediment budget analysis, hydrologic and hydraulic studies, economic analysis, surveys and mapping, engineering and design, cost estimating, structural/electrical/mechanical engineering studies, hazardous/toxic/radioactive waste investigations, real estate studies, plan formulation and evaluation studies, geotechnical studies, and fish and wildlife coordination. The following paragraphs provide a summary of the status of each of these technical study areas at the time of preparation of this Draft Feasibility Report/FSM Read Ahead Report.

1.1.1.1 Public Involvement

Public workshops and meetings have been conducted to actively engage the public on study developments including: with and without-project flooding conditions, flood damage reduction measures, and ecosystem restoration measures. A large part of public involvement activities to date has been be to heighten awareness of the general public about the significant flood threat that currently exists in the entire Skagit River floodplain. Levee overtopping and/or failure during winter flood events can result in significant danger to human life and catastrophic property damage. Skagit County believes it has a responsibility to address and reduce these problems for its residents.

In August 2008, the PDT held a public meeting to present measures under consideration by the project for inclusion in the initial range of alternatives. The PDT solicited comments and provided generalized responses. A majority of the comments indicated support or opposition for various measures which will be taken under consideration once the PDT begins formulating alternatives. Other comments requested additional technical information which the PDT will answer via technical reporting.

In February 2009, members of the PDT invited several resource agencies to a coordination meeting to describe the project measures currently under consideration. Turnout at the meeting was limited indicating to the PDT that further coordination would be more productive once the PDT was able to present a range of alternatives and impact analysis.

The project has not issued a Notice of Intent to complete an EIS to initiate a formal scoping period, as is required by NEPA, in the Federal Register. Public involvement activities to date are consistent with NEPA scoping, however, the PDT made the determination to delay official scoping in order to develop a range of alternatives to present during scoping. It is the opinion of the PDT that this tactic will provide the greatest amount of substantive agency and public comment.

Subsequent public involvement efforts will concentrate on providing additional information on the relative merits of flood damage reduction measures and alternative plans which emerge from the plan formulation and screening process. A communication plan for the feasibility study has been developed and is presented in Section 5 of the study’s Project Management Plan (PMP). The public will be engaged to obtain input on these measures and alternative plans as a comprehensive flood risk management and ecosystem restoration plan is formulated and evaluated. Extensive public involvement and coordination will continue to be conducted throughout the study, including public workshops, public meetings, interagency coordination meetings, newsletters and public notices. These forums will provide opportunity for exchange of information and views with local, state and federal government agencies, Native American tribes, special interest groups, diking and drainage districts, and the general public.

1.1.1.2 Surveys and Mapping

Surveys and mapping work for the lower basin have been completed. Skagit County provided LIDAR and cross-section information for the Skagit River and additional survey information on the upper river basin was developed by Puget Sound Energy was incorporated into the feasibility study.

Selected old river sections were resurveyed to confirm that the basic geometry of the river channel had remained relatively constant over time. Other than the resurvey sections, the river sections from previous design studies were used for the UNET hydraulic model. To provide topographic input for the FLO-2D model, a new aerial photogrammetric survey was conducted for the entire Skagit/Samish floodplain downstream of Sedro Woolley, producing maps showing plan metric details and extensive spot elevations (at grade breaks, road and railroad alignments and 56 miles of sea dike profiles) with a vertical accuracy of +/- 0.5 foot. In addition, profiles of the 60 miles of existing flood control levees were obtained by field methods. All fieldwork was performed by Skagit County, with office work performed by the Corps.

Additional survey and mapping work was conducted. During and after the October 2003 flood event, many diking districts extensively modified levees, including height and cross-sectional width. Survey profiles were needed every 100 feet, and cross-sections every 200 feet, at locations where levee modifications were made by diking districts both during and after the flood event. New bathymetry was also developed downstream of Sedro Woolley, from river mile (RM) 17.5 to RM 22.4. Skagit County and its consultants performed all fieldwork.

1.1.1.3 Geomorphology and Sediment Transport Analysis

A baseline fluvial geomorphology report has been prepared for the Skagit River basin. The report describes the basin-wide sediment budget and the geomorphology of the river and delta channels, and the nearshore areas. The sediment budget was developed to estimate the volume of sediment delivered to the project area from upstream source areas and the significance of storms in sediment delivery. The geomorphic analysis described the channel form, abundance of large woody debris, and evaluated long-term trends in channel aggradation. These are important factors that have shaped the existing stream system and will influence the impacts of any flood damage reduction measures that may be implemented.

The primary objective of these studies was to appropriately describe the physical context in which to evaluate flood damage reduction measures. The geomorphic assessment and sediment transport analysis provides a basis for evaluating the potential interactions between ongoing geomorphic processes and potential flood damage reduction measures.

Development of the sediment budget and sediment transport analysis, coupled with the results of the hydraulic modeling, provide a basis for quantitative assessment of the physical and morphological changes in the Skagit River under with and without project conditions. The sediment budget was developed to approximate the volume of sediment delivered to the project area from upstream. This provided context for the sediment transport modeling effort and provided a basis for evaluating long-term trends in channel aggradation. Sediment transport within the project area was modeled to include modeling of bank erosion, riverbed scour, sediment transport, and deposition within the project area to quantify anticipated changes in channel morphology. This will facilitate evaluation of potential geomorphic effects including over bank sedimentation of alternative flood damage reduction measures and combinations of measures.

1.1.1.4 Geotechnical Studies

Evaluation of the Probable Failure and Probable Non-Failure Points points for the existing levee system was completed and incorporated into the hydraulic model and analysis conducted to date. Currently the levee failure analysis is being updated to be consistent with current guidance and to reflect recent local levee improvements. This work is underway in FY2009.

1.1.1.5 Hydrology and Hydraulics

Hydrologic and hydraulic analyses are being conducted for the feasibility study to identify water depths and floodplains for a range of hydrologic events under with and without project conditions. Initial modeling of without project conditions has been conducted but may require updating based upon findings of ongoing geotechnical analyses of expected levee failure locations. Limited hydraulic modeling of specific measures and combinations of measures has been conducted.

The results of these analyses will provide input to: evaluate the hydraulic effects of combining measures into project alternatives, the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) model for economic analysis of measures and alternatives, and identify potential hydraulic impacts of alternatives for NEPA EIS and ESA consultation. After completion of the Geotechnical Update, it will be determined if any revision to the hydraulic modeling will be required.

All existing hydrologic data was updated to include recent flood information. The existing Skagit River basin frequency curves were revised, along with the tidal frequency curve. The new hydraulic model covers the entire river floodplain from the Concrete gage (River Mile 54.1) to Skagit, Padilla, and Samish Bays. For the river channel and adjacent open floodplain, UNET and FLO-2D models were developed. To determine flooding levels in the overbank areas in the Skagit/Samish Delta based on different levee failure scenarios, a FLO-2D model was developed for the entire overbank floodplain downstream of Sedro Woolley.

Hydraulic studies were also initiated to evaluate optimal flood control storage that can be utilized at Lower Baker and Upper Baker Dams to reduce flood damages to the Skagit River floodplain. The Baker River hydroelectric Project is owned and operated by Puget Sound Energy (PSE). In accordance with existing 1977 Congressional authority, the Corps operates the Upper Baker Dam for a total of 74,000 acre-feet of storage for flood control, with Federal compensation to PSE for power losses associated with 58,000 acre-feet of flood control storage.

After the model was calibrated to replicate past flood conditions accurately, the existing "without-project" flooding conditions were determined for a range of floods. The model is being used in a "what-if?" analysis to help formulate and screen potential flood risk management measures and help select the location for potential levee overflow segments so that a plan can be selected for detailed design and analysis. A hydraulic technical documentation report was prepared and reviewed. It covers hydraulic analysis methodology, model calibration, UNET and FLO-2D model results and output, and how hydraulic results will be used in developing project outputs. The report includes the background hydrology report prepared for this study.

1.1.1.6 Economics

Economic analysis is being conducted to estimate without and with project flood damages in the basin and to screen the identified flood risk management and ecosystem restoration measures. The Corps of Engineers HEC-FDA model is being applied to calculate without project expected damages and damages prevented, by measure, and then by alternatives.

To date an initial assessment of without project damages has been identified using the Corps HEC-FDA model. The resulting economics report will be updated as necessary prior to the completion of the feasibility study (economic data is valid for only 3 years and original data collection was conducted in

1999-2000). Various combinations of measures and alternatives will be modeled in the future. Additional analyses to be completed in the future include:

- Incremental analysis of flood risk management and ecosystem restoration alternatives
- Update of flood damage in the basin
- Development of benefit-to-cost ratios for measures and alternatives
- Identification and evaluation of Other Social Effects and Regional Economic Development benefits
- Identification of net benefits for each alternative, and the identification of the National Economic Development (NED) plan for Federal cost sharing purposes

1.1.1.7 Environmental and Cultural Studies

Environmental and cultural studies are being conducted to evaluate ecosystem restoration opportunities; to support preparation of a NEPA EIS, cultural resources reports, and Biological Assessment; and to ensure compliance with the Corps Environmental Sustainability requirements.

Analysis of existing fish and wildlife habitat and cultural/historic features within the study area has been completed for both the Upper and Lower Skagit Basins. This work included review of existing information and supplemental environmental analysis coordinated with tribal nations, resource agencies, the county, and the public. Existing wetland inventories of the Skagit Basin need to be updated. Sediment data needs to be collected to help refine the sediment budget for the river and the geomorphic and hydraulic analysis of the system. A cultural resources inventory will need to be conducted along project alignments to compensate for gaps in existing surveys.

Design and implementation strategies during further development of measures and alternatives will be applied to minimize the impacts of the recommended plans and to identify ecosystem restoration opportunities. Additionally, biologists, cultural resources and historic staff will evaluate effects of proposed measures and alternatives and will identify proposed mitigation requirements of the recommended plans. ESA coordination will include consultation with USFWS and NOAA.

Modeling will be used to develop restoration strategies for the project. Efforts to certify models appropriate for fish habitat restoration are currently underway to receive nationwide certification. In the event that the certification can be received without impacting the schedule, the project will move forward with using that model. If necessary, the project may attempt to have the model used for the project only should the nationwide effort not be timely.

1.1.1.8 Fish and Wildlife Coordination Act Compliance

Coordination with USFWS, as required by the Fish and Wildlife Coordination Act will include, interagency and tribal coordination, planning and evaluation of the impacts of alternative measures and plans on fish and wildlife resources, preparation of planning aid letters, and a draft and final Fish and Wildlife Coordination Act Report for inclusion in the feasibility report. The Corps received a planning aid report dated 12 August 1997, and several subsequent planning aid letters dated 10 October 2000, 7 May 2001, and 30 October 2001. Further coordination with USFWS is necessary; the draft and final Coordination Act Reports will need to be prepared to fully comply with the FWCA.

1.1.1.9 Hazardous, Toxic, and Radioactive Waste Analysis

A literature review of HTRW issues in the Skagit Basin was conducted. No HTRW sampling or evaluation was conducted. There is a HTRW site on the left bank down stream of Mt. Vernon that historically served as a dump site. Studies will be conducted as appropriate based on identification of alternatives.

1.1.1.10 Engineering and Design

Preliminary designs for flood risk management measures will be based on designs developed by Skagit County, the Corps, and information provided by Puget Sound Energy. Skagit County will perform the design of measures and alternatives, with the exception of modifications to dams. In the future development of the feasibility study, designs for mitigation and ecosystem restoration projects will be designed in coordination with the Environmental Advisory Committee, a committee composed of local stakeholders and the tribes. Restoration projects will be tied to flood risk management projects where possible.

1.1.1.11 Structures/Electrical/Mechanical Analysis

Skagit County will develop design for bridge and weir projects associated with flood risk management or ecosystem restoration alternatives.

1.1.1.12 Real Estate

To date, Skagit County has provided real estate data to support 10% design based upon tax assessor's data and preliminary measure footprints. Potential measures include relocations. As alternatives are developed, additional real estate requirements will be developed. A detailed Real Estate Plan will be developed for the recommended plan.

1.1.1.13 Cost Estimating

Cost Estimating will be conducted to provide the costs for constructing and maintaining flood risk management measures and combinations of measures in the study area based on data provided by civil engineers and real estate. To be included in all project costs are disposal sites; levee material; building materials; equipment; labor; and real estate for land acquisition or use, relocations, and other estate issues. An MCASES M2 cost estimate will be prepared for the recommended plan and if necessary locally preferred plan.

1.1.1.14 Plan Formulation and Evaluation

Plan formulation tasks completed to date include identification and documentation of flood risk management and ecosystem restoration problems and opportunities in the study area, specification of project planning objectives and constraints, documentation of major planning assumptions, identification of an array of flood risk management measures, and preliminary screening of identified measures. Screening criteria identified to date include hydraulic performance, preliminary economic benefits/costs, and environmental concerns. The following plan formulation and evaluation activities are being or will be conducted:

1. Updates of analysis and reports documenting Without Project Conditions, with technical review;
2. Completion of a Feasibility Scoping Meeting with the vertical team (Headquarters, Northwestern Division, Seattle District and Skagit County staffs);
3. Completion of an Alternative Formulation Briefing with the vertical team (Headquarters, Northwestern Division, Seattle District and Skagit County staffs);
4. Screening of flood risk management measures and development of an array of alternative plans for detailed evaluation.
5. Formulation and evaluation of non-structural flood risk management measures and ecosystem restoration measures.
6. Ecosystem restoration measures that are compatible or could be implemented in conjunction with recommended flood risk management measures will be evaluated for costs and ecosystem

outputs by applying cost effectiveness and incremental cost analysis procedures developed by the Corps Institute for Water Resources.

7. Combinations of measures will be developed into alternatives to address identified planning objectives and constraints while meeting four criteria: completeness, effectiveness, efficiency, and acceptability.
8. Identification of the National Economic Development Plan (NED). Because ecosystem restoration is also a project purpose, an alternative will be recommended that optimizes ecosystem benefits with consideration to costs in combination with the NED plan. Because ecosystem restoration is not an equally competing project purpose to flood risk management, no National Ecosystem Restoration (NER) alternative is planned to be identified or selected. However, the NED plan will give full consideration to incorporation of compatible ecosystem measures in order to provide ecosystem benefits.

Feasibility Study Status

The following sections provide a summary of the status of the feasibility study as of the time of preparation of this Feasibility Scoping Meeting Read Ahead Document. Any known sensitive policy issues are identified, the status of Agency Technical Review (ATR) is documented, a current Study Schedule is provided, the status of the Project Management Plan is discussed, and any previous guidance memoranda are addressed.

Planned Technical Study Updates

As noted in Section 4.2, revised studies are planned for geotechnical levee stability analysis, hydrologic and hydraulic modeling, and economic damage modeling. These revised analyses will support continued plan formulation and plan comparison during the remainder of the feasibility study.

USACE Policy Compliance Issues

Corps of Engineer's Regulation ER115-2-100 Appendix G, amended June 2004, cites sensitive policy areas that should be assessed specific to both Flood Risk Management and Ecosystem Restoration projects. The cited issues were evaluated for applicability to this study and are summarized in Tables 4-1 and 4-2.

Table 4-1. Sensitive Policy Areas Specific to Flood Damage Reduction

For projects with a flood damage reduction component, answering yes to any of the following questions will require coordination through the vertical team. A complete description of the issues will need to be provided in each case. *(ER 1105-2-100; Appendix G, Amendment #1; 30 June 2004)*	
Is the project for protection of a single property or beneficiary?	NO

Is the project producing land development opportunities/benefits? (If land creation benefits are expected to occur, describe whether special cost sharing should apply.)	NO
Is there any recommendation to cost share any interior drainage facilities?	NOT AT THIS TIME
Are there any windfall benefits that would accrue to the project sponsor or other parties? (If windfall benefits are expected to occur, describe whether special cost sharing should apply.)	NO
Are there non-structural buyout or relocation recommendations? If yes list the authority and describe what is proposed.	NON-STRUCTURAL BUYOUT OR RELOCATION MEASURES ARE UNDER CONSIDERATION.
Are the reallocation studies likely to change the existing allocated storage in lake projects?	REALLOCATION OF STORAGE IN NON-FEDERAL LAKE PROJECTS IS UNDER CONSIDERATION

Table 4-2. Sensitive Policy Area Specific to Ecosystem Restoration

For projects with an ecosystem restoration component, answering no to any of the following questions will require coordination through the vertical team. A complete description of the issues will need to be provided in each case. *(ER 1105-2-100; Appendix G, Amendment #1; 30 June 2004)*	
Has the project been formulated using cost effectiveness and incremental analysis techniques?	COST EFFECTIVENESS AND INCREMENTAL COST ANLAYSES WILL BE APPLIED IN FORMULATION AND EVALUATION OF MEASURES FOR ECOSYSTEM RESTORATION
Was “IWR Plan” used to do cost effectiveness/incremental analysis?	IWR-PLAN OR IWR PLANNING SUITE WILL BE APPLIED TO CONDUCT CEA-ICA IN SUBSEQUENT STUDY PHASE
Are all the benefits aquatic?	TO BE DETERMINED AS ECOSYSTEM RESTORATION MEASURES ARE FORMULATED
Has the significance of the habitat been clearly identified? Describe the basis for determining the significance.	HABITAT SIGNIFICANCE WILL BE DOCUMENTED IN SUBSEQUENT STUDY PHASE
Are all the proposed recreation features in accord with ER 1105-2-100, Appendix E, Exhibit E-3?	AT THIS TIME NO RECREATION FEATURES ARE INCLUDED IN MEASURES UNDER CONSIDERATION
Has the restoration project been formulated for biological/habitat values as opposed to, for example, water quality?	ECOSYSTEM RESTORATION MEASURES WILL BE FORMULATED FOR HABITAT VALUES IN SUBSEQUENT STUDY PHASE

For projects with an ecosystem restoration component, answering *yes* to any of the following questions will require coordination through the vertical team. A complete description of the issues will need to be provided in each case.	
Is the project purpose for restoration of cultural or historic resources as opposed to ecosystem restoration?	NO
Is there mitigation authorized or recommended?	FLOOD CONTROL FEATURES ARE LIKELY TO REQUIRE MITIGATION. RECOMMENDATIONS WILL BE DEVELOPED IN SUBSEQUENT STUDY PHASE
Are there recommendations for other than restoring a degraded ecosystem ([e.g., creating new habitat where it has never been)?	NOT AT THIS TIME
Is the project on non-public lands?	TO BE DETERMINED
Does the project involve land values > 25% of total project cost?	TO BE DETERMINED
Are there recommendations to include water quality improvements?	NOT AT THIS TIME
Is the monitoring and adaptive management period proposal beyond 5 years after completion of construction?	NOT AT THIS TIME
Does the proposal involve land acquisition in other than fee title?	TO BE DETERMINED
Are there recommendations for non-native species?	NOT AT THIS TIME
Does the project propose the use of navigation servitude?	NO

Agency Technical Review Status

Corps of Engineers guidance requires that an Agency Technical Review (ATR) is conducted to ensure the product is consistent with established Corps criteria, guidance, procedures, and policy. The ATR will assess whether the analyses presented are technically correct and comply with published USACE guidance, and that the documents explains the analyses and results in a reasonably clear manner for the public and decision makers. Products are reviewed against published guidance, including Engineering Regulations, Circulars, Manuals, Engineering Technical letters and Bulletins. Corps personnel external to the Seattle District perform this ATR. Technical disciplines to be represented on the ATR will, at a minimum, include hydrology and hydraulics, economics, environmental, cultural, design, real estate, cost estimating, and plan formulation. All decision documents require ATR. A detailed Peer Review Plan has been approved by Corps Division offices and the Centers of Expertise for Flood Risk Management and Environmental Restoration and is posted at their website. Policy issues will be reviewed by Corps Division and Headquarters, and the Chief of Engineer's office. EC 1105-2-410 appendix C, page 4 provides additional review criteria. Reference: ER 1105-2-410, Review of Decision Documents, 22 August 2008.

At the time of production of this report, the studies summarized in Section 5 of this report, Without Project Conditions have completed Agency Technical Review (ATR). Table 4-3 provides the status of ATR at this time. Any subsequent revisions or updates to these previously completed analyses/documents that have completed ATR will require a new ATR of revised work.

Table 4-3. Agency Technical Review Status

Technical Study Area	Report	ATR Status
Environmental (2009)	Skagit River Flood Damage Reduction Study, Environmental Baseline, Report Upper Basin Skagit River Flood Damage Reduction Study, Environmental Baseline, Report Lower Basin	Complete.
Geomorphic (2009)	Skagit River Flood Damage Reduction Feasibility Study, Skagit River Basin, Sediment Budget and Fluvial Geomorphology	Complete.
Hydrology and Hydraulics (H&H) (2004)	Skagit River Basin, Skagit River Flood Damage Reduction Feasibility Study, Hydrology Technical Documentation 3b. Skagit River Basin, Skagit River Flood Damage Reduction Feasibility Study, Hydraulic Technical Documentation	Complete.
Economics (2004)	Economic Flood Damage Assessment of Without Project Conditions for the Skagit River, Washington Flood Damage Reduction Feasibility Study, Skagit County, Washington	Complete.
Plan Formulation (2009)	Feasibility Scoping Meeting Read Ahead	Complete.

Independent External Peer Review

Independent External Peer Review (IEPR) is the most independent level of review and is applied in cases that meet certain criteria where the risk and magnitude of the proposed project are such that a critical examination by a qualified team outside of USACE is warranted. External Peer Review is conducted by nationally recognized technical experts outside of the Corps of Engineers. The Independent External Peer Review panel will be established by the responsible Planning Center of Expertise through contract with an independent scientific and technical advisory organization.

The scope of the review will address all underlying planning, engineering (including safety assurance) economics, and environmental analyses performed, not just one aspect of the project. The IEPR panel will use appropriate analytical methods for each technical section. The panel will meet with the study PDT and the public to determine areas of controversy in the decision document. If determined necessary, the panel will tour the study area and interview participants as needed. Reference: ER 1105-2-410, Review of Decision Documents, 22 August 2008.

Study Schedule

A summary schedule of key project milestones is presented in Table 4-4. The schedule is based upon project capability and may be impacted by funding. The feasibility schedule will be reevaluated at the beginning of each fiscal year based on available Federal and non-federal funding, and to reflect any changes in study assumptions or tasks based on current information.

Table 4-4. Project Milestones

Deliverable	**Completion**
Feasibility Scoping Meeting	September 2009
Levee Risk and Reliability Report	1st Quarter FY10
Economics Without Project Condition Report	1st Quarter FY10
H&H Without Project Condition Report	2nd Quarter FY10
Feasibility Study Without Project Condition Report	2nd Quarter FY10
Measures Report	2nd Quarter FY10
Screening Technical Memo	2nd Quarter FY10
Environmental Analysis No-Build Report	2nd Quarter FY10
Economic Analysis No-Build Report	2nd Quarter FY10
H&H Analysis No-Build Report	2nd Quarter FY10
Geomorphology Analysis No-Build Report	2nd Quarter FY10
Range of Alternatives Report	3rd Quarter FY10
NEPA Scoping Meetings/Process Including NOI and report	3rd Quarter FY10
Environmental Alternative Analysis Report	4th Quarter FY10
Economic Alternative Analysis Report	4th Quarter FY10
Geomorphology Alternative Analysis Report	4th Quarter FY10
H&H Alternative Analysis Report	4th Quarter FY10
NEPA Open House Including Report	4th Quarter FY11
35% Design on measure consistent across measures	4th Quarter FY11
Environmental Additional Alternative Analysis Report	1st Quarter FY11
Economic Additional Alternative Analysis Report	1st Quarter FY11
Geomorphology Additional Alternative Analysis Report	2nd Quarter FY11
H&H Alternative Additional Analysis Report	2nd Quarter FY11
Alternative Refinement and Revised Alternative Analysis Report (including 35% design and Geotechnical Investigations)	2nd Quarter FY11
Alternative Formulation Briefing Meeting	3rd Quarter FY11
NEPA Open House Including Report	4th Quarter FY11
Dam Waiver	1st Quarter FY12

Deliverable	Completion
Draft Feasibility Study Report	1st Quarter FY12
Draft Environmental Impact Statement	1st Quarter FY12
Final Feasibility Study Report	3rd Quarter FY12
Final Environmental Impact Statement	3rd Quarter FY12

The project development team currently has set completion of the project in FY 2012.

Proposed Changes to PMP

A draft revision to the Project Management Plan was completed in May 2009 and is currently under review. Proposed changes of note include:

- The amended Project Management Plan proposes to increase the feasibility study cost from $6,852,180 to $14,465,180, an increase in total costs of $7,613,000. The total project cost is to be split 50/50 by each jurisdiction.
- The PMP was updated to reflect current members of the project's Project Delivery Team, Executive Committee, and Environmental Advisory Committee.
- The PMP includes a revised study schedule that has been updated to reflect current status of deliverables as well as a new estimate of future annual funding, as can be seen above in Table 4-4.
- The PMP includes specific identification of screening criteria to be employed for screening flood risk management measures (these screening criteria are presented in Section 6.5 of this FSM Read-Ahead Report).
- The PMP includes revised specification of the NEPA Scoping process including milestones and division of Federal/non-Federal responsibilities.
- The PMP was revised to reflect current Corps requirements for quality control, Agency Technical Review, and Independent External Peer Review.
- The PMP was revised to provide an updated Communication Plan that identifies challenges, goals, target audiences, key messages, and strategies.

NEPA Compliance

In compliance with NEPA, the PDT will submit a Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for the Skagit River GI feasibility phase. The NOI will trigger a required 30 day period for agencies and citizens to comment on the Purpose and Need of the project, the inventory of baseline conditions, and the Range of Alternatives.

As part of the scoping process, it is anticipated that the PDT will conduct a series of public open houses in locations around Skagit County to inform the public and solicit comments. Additionally, the PDT will coordinate and present materials to environmental regulatory agencies with special interest in the project, via the Environmental Advisory Committee, as part of early and consistent coordination on environmental regulatory issues and ecosystem restoration aspects of the project.

This process will result in a Scoping Report documenting the scoping processes legal sufficiency to comply with NEPA as well as providing a log of comments submitted for ongoing review and reference by the PDT.

The project will be conducted in coordination with the Environmental Advisory Committee made up of Federal, tribal, State, local, and private groups with natural and cultural resource interests. Input with regard to alternatives and analysis methodology will be solicited from this group to ensure that project outcomes meet compliance requirements of several environmental and cultural resource laws as well as tribal treaties. This committee will accomplish the majority of cooperating agency consultation for the project.

The project will culminate in an integrated Feasibility Study/Environmental Impact Statement. Environmental planning will be utilized to the greatest extent possible to avoid, minimize and finally mitigate for impacts resulting from the proposed plan.

WITHOUT PROJECT CONDITIONS

This chapter summarizes without project conditions related to flooding and ecosystem conditions in the study area. The technical areas summarized include hydrology and hydraulics, geomorphology and sedimentation, economics, and environmental resources. Further documentation of these technical areas can be found in the technical appendices to this Draft Feasibility Report/FSM Read-Ahead Report.

Hydrology and Hydraulics

The hydrology and hydraulics data in this report are from the work completed and reviewed in 2004. Updates to the analyses incorporating more current data are in progress at the time of this report. Future iterations of the feasibility report will incorporate revised analyses following completion and formal review of the new data.

Hydrology

The Skagit River basin is located in the northwest corner of the State of Washington. The basin extends about 110 miles in the north-south direction and about 90 miles in the east-west direction between the crest of the Cascade Range and the Puget Sound. The northern end of the basin extends 28 miles into Canada. 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, with headwaters above elevation 6,000 feet. The upper reaches of nearly all tributaries are situated in precipitous steep-walled mountain valleys.

The Skagit River basin is subject to rain and snowmelt runoff during the fall and winter, and snowmelt runoff during the spring. Fall rain storms typically cause the largest floods on the Skagit River. Spring snowmelt runoff is characterized by a relatively slow rise and long duration. Highest mean monthly snowmelt discharges are usually reached in June. The resulting runoff occasionally inundates low areas adjacent to the river but rarely reaches the major damage stage. The Skagit River and all of its major tributaries usually have low flows during August and September after the snowpack has melted and the groundwater flow has been partially depleted. A summary of streamflow data for the Skagit River system is provided in Table 5-1.

Table 5-1. Summary of Streamflow Data in CFS[1]

STREAM GAGES	Drain. Area (SqMi)	Period of Record	Years of Record	Avg. Annual Discharge	Max. Annual Discharge	Min. Annual Discharge	Max. Inst.	Min. Inst.
Skagit River at Newhalem	1,175	'08-'14, '20-'99	91	4,419	6,858	3,074	63,500	54
Sauk River near Sauk	714	'11-'12, '28-'99	71	4,364	6,048	2,887	98,600	572
Baker River below Anderson Cr.	210	'10-'25, '28-'31	25	2,073	2,600	1,540	36,800	219
Baker River at Concrete	297	'10-'15, '43-'99	60	2,665	3,543	1,712	36,600	30
Skagit River near Concrete	2,737	'24-'99	75	15,090	21,270	9,629	160,000	2,160
Skagit River near Sedro Woolley	3,015	'08-'24, '75-'79	86	16,150	22,150	10,700	220,000	2,830
Skagit River near Mt. Vernon	3,093	'41-'99	59	16,680	23,140	10,510	152,000	2,740
1 - Data from USGS Water Resource Data through year 1999 (Streamflow in cfs). Period of Record for Max. and Min. "Average Annual Discharge" begins as follows: Newhalem '61, Sauk '29, Baker '44, Concrete '25, Mount Vernon '25.								

Historical floods experienced in the Skagit River basin through 2003 are briefly described below:

- **Flood of 1949.** The flood of November 1949 is a good example of a flood crest flattening while moving downstream. Channel storage had a marked effect on the sharpness of the peak between Concrete and Mount Vernon. The peak discharge of 154,000 cfs at Concrete was reduced to 114,000 cfs at Mount Vernon. An absence of precipitation in the lower basin at the time of this flood partially explains the reduction in crest in the lower reaches of the channel. The Sedro-Woolley precipitation gage indicated that very little rain fell in the lower part of the basin.

- **Flood of 1951.** The February 1951 flood had a peak discharge of l39,000 cfs at Concrete, a recorded peak of l50,000 cfs at Sedro-Woolley, and a peak of l44,000 cfs at Mount Vernon. Reservoir storage reduced the peak discharge at Concrete about l3,000 cfs. However, due to the long duration of the peak discharge between Concrete and Mount Vernon, channel storage and attenuation had little effect on reducing the peak stage in the lower reaches. The flood remained near its peak for 6 hours at Mount Vernon. The duration of this peak was more significant than its magnitude because it minimized the effectiveness of natural storage in the Nookachamps Creek area, and dikes failed because they lacked sufficient cross-sectional dimensions to withstand a long period of high water.

- **Floods of 1990.** The month of November 1990 included significant floods on November 9-11 (the first flood) and November 24-25 (the second flood). The first flood was slightly larger in volume than the second flood, but peak discharges were similar during both floods, having approximately a 5 percent exceedance frequency at the Concrete streamgage. During the first November 1990 flood event, the peak discharge of 149,000 cfs at Concrete increased to 152,000 cfs at Mount Vernon. Upstream flood storage during these events amounted to approximately 194,000 acre-feet during the first flood and approximately 153,900 acre-feet during the second flood. The above volumes include 112,000 acre-feet stored in Ross and 82,000 acre-feet stored in Upper Baker during the first and 100,000 acre-feet stored in Ross and 53,900 acre-feet stored in Upper Baker during the second flood. Inflow to both projects peaked on November 10, 1990 (first flood) as follows; 46,000 cfs at 2400 hours at Ross, and 33,000 cfs at 1000 hours at Upper Baker. Outflows at both projects were regulated to a minimum of 5,000 cfs through the main part of the flood.

  Both events required extensive flood fighting in the vicinity of Mount Vernon. Many requests were received by the Seattle District Reservoir Control Center from flood engineers at Mount. Vernon to hold the stored floodwater and limit the rate of storage discharges to provide time for recession of the River's uncontrolled streamflows.

  A major levee break occurred during the first flood on the eastside of Fir Island, the major farming region between the North and South Forks of the Skagit River about 3 miles downstream from Mount. Vernon. The failure occurred about 12-14 hours before the peak at Mount Vernon, inundating most of Fir Island and causing major damages. The Fir Island levee failure caused Skagit River water surface elevations to fall abruptly as the island filled with water. The hydraulic relief provided by the Fir Island levee failure was probably instrumental in preventing failure of other major levees in the vicinity. Emergency repairs to the Fir Island levee were made between the first and second floods, but time was insufficient to fully stabilize the levee and the levee failed again during the 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 floodplain ponding from the first flood.

- **Flood of 1995.** 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 zero damage stage for four days and above major damage (90,000 cfs) for one and a half days. Mount Vernon was above zero damage stage for approximately 4 days and 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. Runoff stored at Ross and Upper Baker was estimated to have reduced flood levels by about 5 feet and 2 feet at Concrete and Mount Vernon, respectively.

  The Seattle District Reservoir Control Center (RCC) took control of Ross flood control storage on November 28th when the National Weather Service forecast a storm that would produce record-level flooding. Ross filled to an elevation of 1,602.38 feet on November 30, using 118,623 acre-feet of the total active flood-control storage of 120,051 acre-feet. Ross inflow peaked at about 46,500 cfs at 1400 hours on November 29th shortly after the Skagit River near Concrete had peaked at 160,000 cfs. Discharges at Concrete had receded to 90,000 cfs by the afternoon of the 30th. Efforts to increase discharge and pass inflow at Ross were delayed nearly two days by the high inflow and the limitation on discharge of 26,000 cfs-28,000 cfs through the Project.

  On November 28th at 1135 hours, RCC took control of Upper Baker flood control storage when the reservoir was at elevation 707.9 feet. Upper Baker Dam filled to an elevation of 719.1 feet on November 30, using 63,800 acre-feet of the 74,000 acre-feet of total flood-control storage at Upper Baker. Peak inflow into Upper Baker was 31,000 cfs. This flood set a new crest-stage record at the Concrete gage despite the regulation at Ross and Upper Baker. 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.

  Reservoir inflow caused Ross Lake to fill to elevation 1,602.38 feet, which is within 0.12 feet of the maximum full flood control pool. Upper Baker started to evacuate storage at 1800 hours on November 30, nearly a day after the River crested at Concrete. The flood storage evacuation was delayed until the flow at Concrete receded below 90,000 cfs in response to reports from the field flood engineers indicating that levees were still holding but a prolonged duration of high river flow was likely to cause failure. Mount Vernon was 0.5 foot above major damage for an extra half day, but the initial height was reduced due to this special evacuation.

- **Flood of 2003.** 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 zero damage stage for 57 hours and above major damage (90,000 cfs) for 33 hours. Mount Vernon was above zero damage stage for 64 hours and 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. 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 the November 1995 and November 25, 1990 flood.

The Upper Skagit River Basin has 1,296 square miles of drainage area that is behind dams that currently have reservoir space set aside for flood control and 1,441 square miles that is uncontrolled. The Upper Skagit River from Concrete to Ross Dam has numerous tributaries flowing into it. Most of the large tributaries have long stream gage records.

Nine storm events, corresponding to the 2-, 5-, 10-, 25-, 50-, 75-, 100-, 250-, and 500-year recurrence intervals in the basin, were simulated for the feasibility study. Peak discharges from this modeling at three key locations, Concrete, Sedro-Woolley, and Mount Vernon, are summarized in Table 5-2.

Future changes to the study area hydrology (for example, due to climate change or future development) have not been modeled or incorporated into the analysis for the study.

Table 5-2. Peak Flows

Recurrence	Unregulated Concrete	Regulated Concrete	Unregulated Sedro-Woolley	Regulated Sedro-Woolley	Unregulated Mount Vernon	Regulated Mount Vernon
2-year	72,900	72,900	78,100	78,100	75,700	75,700
5-year	119,400	93,900	124,300	99,400	116,500	97,300
10-year	156,000	120,400	160,600	125,100	142,700	117,400
25-year	205,300	158,000	210,300	163,400	199,400	146,000
50-year	248,100	192,100	252,000	198,500	233,700	190,900
75-year	276,500	215,500	280,200	222,600	257,000	212,400

Recurrence	Unregulated Concrete	Regulated Concrete	Unregulated Sedro-Woolley	Regulated Sedro-Woolley	Unregulated Mount Vernon	Regulated Mount Vernon
100-year	297,100	235,400	298,600	242,000	273,900	230,100
250-year	372,200	320,200	368,100	319,800	334,000	289,800
500-year	437,000	386,900	429,900	380,800	396,700	346,400

Hydraulics

1.1.1.15 Upper Basin Characteristics

The Skagit River from the U.S.-Canadian Border to Gorge Dam flows through the three Skagit River Plants (i.e. Ross, Diablo, and Gorge) in a hydraulically-connected reservoir waterway. The 15,000-foot long reach between Gorge Dam to the Gorge Powerhouse is usually dry during normal hydropower operations. However, during flooding, local runoff generally fills the limited storage space in Gorge Lake prior to the flood peak, causing Gorge to spill into the normally dry channel between the dam and the Powerhouse. When the channel below Gorge reaches its capacity, releases from Ross can be routed to Newhalem in a half hour or less, provided the spill gates at Diablo and Gorge are also open.

The reach from Newhalem to Concrete falls approximately 8 feet per mile. This reach is 39.6 miles long. The upper half of the reach contains a steep rugged channel located between narrow rock canyon walls in many places. Most of the channel bed is composed of large irregular-shaped boulders, rocks, and cobbles. Within this reach, the Skagit River flows in a series of water drops and deep pools. The lower half of the reach is more placid with a flatter channel with smaller rocks and gravel materials. Hydraulic travel time from Newhalem to Concrete is approximately 8 hours at the higher range of flows that occur during flood conditions.

The reach from Concrete to Mount Vernon falls approximately 150 feet (an average of about 3.9 feet per mile). This reach is 38.4 miles long. River gradients range from 5.3 feet per mile near Concrete to 1.5 feet per mile below Sedro-Woolley. Hydraulic velocities vary according to the location along the Skagit River, ranging from 5 feet per second (fps) to 10 fps. This reach is comparatively placid with a wide, gravel-lined channel with mostly small cobbles and gravels, soil embankments, and numerous side channels, oxbows, and overbank erosion scars created during large floods of the past. Travel time through this reach varies with the rate of discharge, decreasing from 15 to 20 hours at low flow to between 10 to 15 hours at higher discharges.

1.1.1.16 Hydraulic Reaches and Channel Characteristics

The project area has been divided into ten main reaches for overall description, analysis, and reporting purposes, as shown on Table 5-3. These reaches are associated with representative index location from the hydraulic model. The reaches are shown on **Plates 10 and 11**, and are referred to as Downstream and Upstream Study Reaches.

Table 5-3. Skagit River Project Reaches

Reach	Description	Downstream Terminus (River Mile)	Upstream Terminus (River Mile)
1	Right Bank: Northern portion of the study area and includes the City of Burlington, WA, and the community of Sterling, WA.	MS 15.1	MS 22.4
2	Right Bank and Includes West Mount Vernon.	MS 10 NF 0	MS 15.1 NF 9.25
3	Fir Island between the North and South Forks of the lower Skagit River.	SF 0 NF 0	SF 9.25 NF 9.25
4	Left Bank and includes those portions of the City of Mount Vernon to the east of the river.	MS 10 SF 0	MS 15.1 SF 9.25
5	Big Bend and includes a water treatment plant.	MS 13.15	MS 16.8
6	Left Bank and includes the lower Nookachamps Creek Basin and the community of Clear Lake.	MS 15.1	MS 22.4
7	Town of La Conner.	NA	NA
8	Part of Sedro Wooley	MS 22.4	MS 27.04
9	Town of Lyman	MS 27.04	MS 38.15
10	Town of Hamilton	MS 38.15	MS 54.35

Past floods have demonstrated that levee failures in the lower reaches (Reaches 1 to 5) can inundate broad areas of the floodplain. At the upstream reaches (Reach 6 and 8 to 10), inundation primarily occurs as flows rise within the channel and spill out onto the floodplain as opposed to the levee breaks that initiate damages in the lower reaches. Table 5-4 includes the stage discharge function for each reach by flood event.

Table 5-4. Skagit River Rating Stage Discharge Function by Event and Reach

Reach/Event*	Index Location (River Mile)	Average Conditions	
		Flow	Stage
2-year			
Hamilton (Right Bank)	40.155	87573	96.23
Lyman (Right Bank)	31.45	95663	64.12
Sedro-Woolley (Right Bank)	22.8	91896	42.11
Sedro-Woolley WWTP	22.4	92903	41.24
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	93097	41.11
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	93097	41.11
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	81563	31.33
RM 15.1 to mouth of North Fork (Right Bank)	15.1	84379	28.13
Mount Vernon to Stanwood (Left Bank)	12.96	86323	24.93
Fir Island	SF 8.75	47400	18.33
5-year			
Hamilton (Right Bank)	40.155	97588	96.79
Lyman (Right Bank)	31.45	98857	64.46
Sedro-Woolley (Right Bank)	22.8	99286	42.11
Sedro-Woolley WWTP	22.4	99370	41.24
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	99367	41.11
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	99367	41.11
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	97286	33.07
RM 15.1 to mouth of North Fork (Right Bank)	15.1	97257	29.49
Mount Vernon to Stanwood (Left Bank)	12.96	97230	25.83
Fir Island	SF 8.75	47392	19.27
10-year			
Hamilton (Right Bank)	40.155	124406	98.52
Lyman (Right Bank)	31.45	125589	65.65
Sedro-Woolley (Right Bank)	22.8	125043	43.38
Sedro-Woolley WWTP	22.4	125136	41.79
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	125132	41.65
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	125132	41.65
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	117434	35.67
RM 15.1 to mouth of North Fork (Right Bank)	15.1	117393	31.84
Mount Vernon to Stanwood (Left Bank)	12.96	117356	27.83
Fir Island	SF 8.75	57242	21.07
25-year			
Hamilton (Right Bank)	40.155	162751	100.64
Lyman (Right Bank)	31.45	164277	67.2
Sedro-Woolley (Right Bank)	22.8	163307	45.83
Sedro-Woolley WWTP	22.4	163417	43.88
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	163419	43.68
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	163419	43.68
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	146009	38.92

Reach/Event*	Index Location (River Mile)	Average Conditions	
		Flow	Stage
RM 15.1 to mouth of North Fork (Right Bank)	15.1	145969	34.71
Mount Vernon to Stanwood (Left Bank)	12.96	145932	30.19
Fir Island	SF 8.75	73446	23.36
50-year			
Hamilton (Right Bank)	40.155	197759	102.33
Lyman (Right Bank)	31.45	199575	68.57
Sedro-Woolley (Right Bank)	22.8	198378	48.1
Sedro-Woolley WWTP	22.4	198502	46.08
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	198492	45.85
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	198492	45.85
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	191468	43.37
RM 15.1 to mouth of North Fork (Right Bank)	15.1	190785	38.67
Mount Vernon to Stanwood (Left Bank)	12.96	190739	33.44
Fir Island	SF 8.75	98547	26.54
75-year			
Hamilton (Right Bank)	40.155	222019	103.4
Lyman (Right Bank)	31.45	224192	69.54
Sedro-Woolley (Right Bank)	22.8	222478	49.88
Sedro-Woolley WWTP	22.4	222590	47.95
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	222574	47.73
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	222574	47.73
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	212390	45.39
RM 15.1 to mouth of North Fork (Right Bank)	15.1	212350	40.47
Mount Vernon to Stanwood (Left Bank)	12.96	212321	35
Fir Island	SF 8.75	110816	27.98
100-year			
Hamilton (Right Bank)	40.155	242238	104.24
Lyman (Right Bank)	31.45	244397	70.34
Sedro-Woolley (Right Bank)	22.8	241937	51.63
Sedro-Woolley WWTP	22.4	242034	49.89
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	242013	49.7
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	242013	49.7
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	230151	47.05
RM 15.1 to mouth of North Fork (Right Bank)	15.1	230113	41.92
Mount Vernon to Stanwood (Left Bank)	12.96	230082	36.27
Fir Island	SF 8.75	120890	29.13
250-year			
Hamilton (Right Bank)	40.155	328406	107.47
Lyman (Right Bank)	31.45	330158	73.74
Sedro-Woolley (Right Bank)	22.8	321006	58.27
Sedro-Woolley WWTP	22.4	319851	56.37

Reach/Event*	Index Location (River Mile)	Average Conditions	
		Flow	Stage
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	319808	56.21
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	319808	56.21
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	289833	52.43
RM 15.1 to mouth of North Fork (Right Bank)	15.1	289791	46.3
Mount Vernon to Stanwood (Left Bank)	12.96	289769	40.01
Fir Island	SF 8.75	154873	32.79
500-year			
Hamilton (Right Bank)	40.155	396525	109.72
Lyman (Right Bank)	31.45	398288	76.24
Sedro-Woolley (Right Bank)	22.8	394440	64.41
Sedro-Woolley WWTP	22.4	380819	62.91
Sedro-Woolley to RM 15.1 (Right Bank)	22.27	380759	61.82
Nookachamps (Left Bank from S-W to RM 17.5)	22.27	380759	61.82
Big Bend (Left Bank from RM 17.56 to RM 13.1)	17.52	346409	57.01
RM 15.1 to mouth of North Fork (Right Bank)	15.1	346389	50
Mount Vernon to Stanwood (Left Bank)	12.96	346373	43.1
Fir Island	SF 8.75	187500	36.07
** Event frequencies are approximate and are only intended to show relative magnitude of expected flood discharges.*			

1.1.1.17 Levee Failure Points

A levee breach methodology was applied to determine when simulated flows would cause levees to fail and allow the flows of the river out onto the floodplain. To determine when a levee would fail and at what recurrence interval the levees would fail a Probable Failure Point/Probable Non-Failure Point (PFP/PNP) analysis of the levee system was conducted. To determine the points on the levee system that the levee would fail, geotechnical engineers from the Corps completed an inventory of the levee system. The inventory determined for each reach of the river system where the PNP/PFP elevations would occur. The definition of the PFP and PNP is that when the water surface elevation (WSEL) in the river reached that level the levee would be expected to fail 85 and 15 percent of the time, respectively.

For the average condition, likely failure points (LFP) (50 percent probability of levee failure) are developed for all of the levees along the Skagit River, which is taken as the halfway point between the PFP and PNP. The HEC-RAS model makes its determination of when the levee fails from the water surface elevation halfway between cross sections.

For each project reach, representative index locations were identified for hydraulic modeling. For each index location, elevations were identified where flows would be expected to enter the floodplain either through overtopping riverbanks or levees, or by levee failure as described in the Hydrology and Hydraulics Appendix. The locations of the index points, identified by river mile, are provided in Table 5-5, along with the PFP and PNP elevations used in the modeling.

Currently the levee failure analysis is being updated to be consistent with current guidance and to reflect recent local levee improvements. After completion of Geotechnical Update, it will be determined if any revision to the hydraulic modeling will be required.

Table 5-5. Index Locations

Reach	Description	Index Location (River Mile)	Probable Non-Failure Point (Elevation)	Probable Failure Point (Elevation)	Notes
1	Right Bank, Burlington	MS 17.52	35.1	35.6	-
2	Right Bank, W. Mt Vernon	MS 17.52	35.1	35.6	-
3	Fir Island	SF 5.8	16.0	17.0	-
4	Left Bank, Mt Vernon	MS 12.96	29.0	29.0	PNP and PFP elevations are for Top of bank
5	Big Bend	MS 17.52	35.1	35.6	
6	Left Bank, Nookachamps	MS 22.27	39.4	39.4	PNP and PFP elevations are for Top of bank
7	Town of La Conner	MS 17.52	35.1	35.6	Reach 7 is not adjacent to the river bank. It is a subarea within Reach 2.
8	Sedro Wooley	MS 22.8	54.4	54.4	PNP and PFP elevations are for Top of bank
9	Town of Lyman	MS 31.45	66.0	66.0	PNP and PFP elevations are for Top of bank
10	Town of Hamilton	MS 40.16	98.5	98.5	PNP and PFP elevations are for Top of bank

1.1.1.18 Floodplain Mapping

Without-project floodplains were mapped for the 10-, 25-, 50-, 75-, 100-, 250-, and 500-year floods using the FLO-2D and HEC-RAS hydraulic model results. **Plates 7-9** display the 50, 100, and 500 year floodplains.

Geomorphology and Sedimentation

Analysis of the Skagit River's sediment budget and geomorphology was conducted to provide a baseline to evaluate potential sediment budget and geomorphic impacts of alternative flood damage reduction and environmental restoration measures. The main components of this effort included:

- Annual basin sediment yield estimate
- River and delta channel geomorphology
- Nearshore geomorphology

The study area for sediment budget estimates addressed the uncontrolled portions of the Skagit River basin, downstream of Gorge and Lower Baker dams. The geomorphic analysis focused on the mainstem Skagit River, the North and South Fork channels, and the Puget Sound nearshore.

Based on the results of the sediment budget and fluvial geomorphology analyses, the Skagit River's sediment regime can be fairly well defined. There remains some uncertainty about precise annual values, but long-term trends are clear.

The Skagit River channel is fairly stable with the most migration occurring between Burlington and the Cascade River. Channel alignment upstream of the Cascade River is controlled by natural geology, while downstream of Burlington, the river and estuary channels are controlled by levees and bank protection. The middle reach (Burlington upstream to the Cascade River) has only intermittent bank protection and the active migration zone is up to 2 miles wide. The estuary and nearshore islands are growing, but the Fir Island shoreline is eroding.

The average annual sediment yield at Mount Vernon is in the range of 0.6 to 2.8 mcy/yr. The major sources of sediment are the Cascade and Sauk rivers. Approximately half the basin does not contribute sediment because the sediment is stored in reservoirs. Large storms, those with daily discharges above 50,000 cfs, are a major factor in sediment production, causing upper basin land disturbances and producing an estimated 21 percent of the average annual sediment yield.

Upstream of RM 17, the Skagit riverbed is composed of gravel, cobble, and boulders. Downstream of RM 17 the riverbed and nearshore delta bottom are mainly sand. The 2.8 mcy/yr annual suspended sediment yield at Mount Vernon is composed of approximately 50 percent sand, 50 percent silt and clay. Most of the sand, and all the silt and clay are transported through the lower river and into Skagit Bay.

Since 1931, there has been a consistent long-term trend of sediment deposition in the channels downstream of Sedro-Woolley. This has resulted in an overall average bed elevation increase of approximately 2 1/4 ft since 1931. The bed upstream of RM 15.8 appears to be rising slightly faster than the overall average. Sand deposition has also been occurring in the estuary and on the delta. Islands and marsh habitat have been growing at the mouths of the North and South Forks.

Economics

Economic analysis was conducted to estimate the expected future without project flood inundation damages for the study area. The analysis is based upon geotechnical assumptions regarding levee performance and associated hydraulic modeling results. Currently the levee risk and reliability is being updated to be consistent with current guidance and to reflect recent local levee improvements. After completion of Geotechnical Update, it will be determined if any revision to the hydraulic modeling will be required. If changes in these analyses are required the economic modeling and damages will be updated to incorporate the revised modeling results. Additionally, the economic floodplain data applied for this study was collected in 1999-2000 and is planned for an update and subsequent reanalysis to reflect current conditions. The most recent update of the without project economic analysis was in 2004. The most recent inventory was performed in 1997 and was extrapolated to determine 2004 values. Flood related damages were evaluated over a 50-year period of analysis, damages were computed at October, 2004 price levels, and amortization and present value calculations were based upon the FY06 Federal discount rate of 5 1/8 percent.

The methodologies employed in the economic assessment are in conformance with guidance contained in the U.S. Army Corps of Engineers' Planning Guidance Notebook - Engineering Regulation ER 1105-2-100 (or "PGN"), dated April 22, 2000.   Additional guidance on the risk-based analyses was obtained from the U.S. Army Corps of Engineers' EM 1110-2-1619, dated 1 August 1996, "Engineering and Design - Risk-based Analysis for Flood Damage Reduction Studies." Guidance on agricultural damages was derived from the Corps' Institute for Water Resources' (IWR) "National Economic Development Procedures Manual – Agricultural Flood Damage," IWR Report 87-R-10, dated October 1987.

The damage assessment was conducted by applying the Corps' HEC-FDA model. The flood depth inputs for the damage assessment for reaches 1 through 7 are provided from the Flo2D hydraulic model. Because there are levee sections in these lower reaches, flooding can occur when levees are overtopped or from failures below the top of levee. In the upstream reaches 8-10, modeled floods occur as water surface elevations exceed the top of the channel inundating the surrounding structures. HEC-RAS modeling was used to determine flood depths for reaches 8-10.

A separate @RISK model was used throughout the basin to estimate structure damages using the hydraulic data provided. Damages were estimated for each flood event based on depth of flooding at each structure. Those damages for each event were then linked to stage based on the corresponding frequency. Then, stage-damage curves for each reach and for each damage category were entered into HEC-FDA. The @ RISK model has not been certified nationally or for the project. As such, subsequent updates will employ currently certified models or will pursue model certification for @RISK.

Hydrology and hydraulics are not expected to significantly change for the Skagit River under future conditions. It was assumed that the existing and future flood plains would be the same. Future growth was considered but not included in the calculation of future damages. Skagit county's growth rate has been about 1.5% per year over the last five years with future projected growth rate estimated at about 1 to 1.5 % per year to 2025 (source State of Washington, Office of Financial Management.) Projected development in the existing flood plain would require flood proofing or construction above the base flood elevation for the 100-year event. Based on Corps guidance, losses for flood damage to future development within the 100-yr flood plain cannot be considered in the benefit computations. With this restriction, it was assumed that all future development would occur outside 100 yr flood plain or above the 100 water surface elevation. The remaining 200yr and 500yr event future development damages would have little impact on the future without project expected annual damages and were not estimated. For this study, it was assumed that the future without project damages would not be significantly different from the existing conditions.

Without Project Conditions

For the purposes of the economic study, the river was divided into two sections, Downstream Study Reaches and Upstream Study Reaches. The two sections were divided for several reasons. In the early stages of the study, the project study limit was near Sedro Woolley. At that time, only the Downstream Reaches 1-7 were included. Operational changes to the Baker Dams were considered by Puget Sound Energy during their FERC relicensing effots, the Upstream Reaches 8-10 were added in 2003 to address potential flood damage reduction benefits from additional flood control storage. New data was gathered at that time for the extended study area. Another reason for the division was because different hydraulic models were used for each section. Flo2D was used for the Downstream Reaches to address the 2- dimensional nature of the flood plains where flooding due to levee failures is not adequately described by in-channel water surface elevations. HEC-RAS was used for the Upstream Reaches, where levee failure was not the contributing factor to inundation and where more conventional in-channel elevations could be used to determine flood depths. Economic Reaches, known as downstream and upstream Study Reaches, are shown in **Plates 10 and 11**.

1.1.1.19 Land Use and Structure Value

Land use was inventoried for the area likely to be inundated by the 500-year flood event. A complete field survey of all commercial and industrial structures in the flood plain was undertaken. Data collected included structure use, type of construction, structure size, condition, and first-floor elevation. Structure values are based on depreciated replacement value. A field survey of residential properties was conducted to ascertain general characteristics of construction types/classes and average first floor foundation adjustment factors for residential structures in the floodplain.

Structure condition, use, type, and size were used in conjunction with the Marshall & Swift Valuation Service to develop estimates of depreciated replacement costs. First-floor elevation error and standard deviation for risk-based analyses are based on Table 6-5 of EM 1110-2-1619. Risk-based errors and standard deviations for residential depreciated replacement values are based on a triangular distribution, with the upper and lower limits set at Marshall Valuation Service quality of construction grades at one grade above and one grade below, as discussed in Chapter 6-2 of EM 1110-2-1619.

1.1.1.20 Content Value

The risk-based content damage valuation and variation for each residential structure is based on the Economic Guidance Memorandum (EGM) 01-03, Generic Depth-Damage Relationships of 4 December 2000. As specified by the EGM, damage to content is a direct function of structure value, which no longer requires the specific determination of content value. Residential content values were estimated, for comparison purposes only, in determining the total value of property at risk as 50% of the structure value. Non-residential content values were developed from the Lake Pontchartrain Hurricane Protection Plan Report of CH2M Hill, Inc., prepared for the New Orleans District of the Corps of Engineers. These non-residential content values were determined to be representative of the Skagit area due the similarity of land uses, comparable ranges of depths and durations, and were reviewed and approved for use in other Seattle District studies such as the Centralia Flood Damage Reduction Project Chehalis River, Washington.

1.1.1.21 Farm Budget and Crop Data

Agricultural crop acreages were calculated with the assistance of Skagit County. Spatial mapping of agriculture allowed for the overlaying of flood plains to identify flooded agricultural acreage. Various crop budgets were obtained from the Cooperative Extension, Washington State University for northwest Washington (additional crop budgets for blueberries, raspberries and strawberries were obtained from the University of California Cooperative Extension, as these reports were not available in Washington.) Historical crop yields and values for various flood plain crops were obtained from the U.S. Department of Agriculture, National Agricultural Statistics Service for Skagit County. Agricultural land restoration costs are based on previous Corps studies and farm budget reports. Monthly flood probabilities were derived by the Seattle Corps based on the percentage of historical annual peak discharges occurring in each month.

1.1.1.22 Depth Damage Curves

As noted above, single-family residential structural and content damages are based upon the risk-based guidance of EGM 01-03. For non single-family residences, the structural and content inundation damage curves employed are the Federal Emergency Management Agency (FEMA) National Flood Insurance Program's flood insurance rate review depth percent damage curves of 1998 for non-velocity zones. All of the depth-damage curves used in this study can be found in the Economic Technical Appendix to the feasibility report. Agricultural crop losses (damage to the potential harvest due to flooding) have been assumed to be 100% based on conversations with County Agricultural Advisors for reasons of actual loss of crops and the non-marketability of potentially surviving crops, except where noted in the analysis. Therefore agricultural flood damages were based on this 100% loss minus any variable costs not expended.

1.1.1.23 Residential Inventory

In the study area's floodplain there were 12,544 residential units counted from base maps prepared by the Corps of Engineers. The Marshall and Swift Valuation was used to determine the aggregate nominal depreciated structural value of approximately $1,391,784,000[1] that yielded an average residential unit cost of $110,950. The average residential structure is approximately 1,600 square feet in size, which yields a depreciated square foot cost of approximately $69.34, based on a sampling of residential structures in the flood plain. The total nominal content value of these structures is estimated at $695,891,000, or $55,470 per structure. Residential structure and content values by reach are shown below in Table 5-6. Content values were set at 50% of structure value for estimation of total value of property at risk.

---

[1] All dollar values are expressed at an October 2004 price level. The date of the most recent update to the economic analysis.

Table 5-6 - Residential Structure & Content Values

Location	Structures	Structure Value ($1,000)	Content Value ($1,000)
Reach 1 – Burlington	4,790	528,306	264,153
Reach 2 – W. Mt Vernon	2,007	221,359	110,679
Reach 3 – Fir Island	197	21,728	10,864
Reach 4 - Mount Vernon	2,750	303,307	151,654
Reach 5 – Big Bend	88	9,706	4,853
Reach 6 – Nookachamps	465	51,286	25,643
Reach 7 – La Conner	343	37,831	18,915
Reach 8 - Sedro Woolley	1,233	157,879	78,939
Reach 9 – Lyman	175	24,135	12,067
Reach 10 – Hamilton	496	36,247	18,124
Total	12,544	1,391,784	695,891
All dollar values are expressed at an October 2004 price level. The date of the most recent update to the economic analysis.			

1.1.1.24 Nonresidential Inventory

Within the study area there are 1,639 non-residential (agricultural, commercial, public, and industrial) properties with a total floor space of 11,210,860 square feet. The total nominal depreciated structure value of these properties is $656,585,000 with a total content value of $675,728,000. The average cost per square foot of these structures is $58.57. Overall content-to-structure value ratio for these structures is 102.9%. Non-residential structure and content values by location are shown in Table 5-7.

Table 5-7 - Nonresidential Structure & Content Values

	Number	Structure Value (in $1,000's)	Content Value (in $1,000's)	Sq. Footage
Reach 1	357	280,238	298,900	4,244,800
Reach 2	81	33,025	29,594	495,260
Reach 3	420	6,808	5,027	351,300
Reach 4	482	247,156	257,633	4,370,200
Reach 5*	29	15,735	14,992	323,880
Reach 6	24	6,788	6,772	103,830
Reach 7	133	46,996	47,164	859,190
Reach 8	60	15,494	12,092	291,000
Reach 9	28	1,660	1,257	94,600
Reach 10	25	2,685	2,297	76,800
Total	1,639	656,585	675,728	11,210,860
All dollar values are expressed at an October 2004 price level. The date of the most recent update to the economic analysis.				

1.1.1.25 Flood Damage Model

For this Skagit River study, expected annual damages were estimated using the Corps of Engineers risk-based Monte Carlo simulation program called HEC-FDA. The HEC-FDA program integrates hydrology, hydraulics, geo-technical and economic relationships to determine damages, flooding risk and project performance. Uncertainty is incorporated for each relationship, and the model samples from a distribution for each observation to estimate damage and flood risk. The Skagit River model includes the following relationships for each damage reach:

- Probability-Discharge (with uncertainty determined by period of record)
- Inflow-Regulated Outflow (uncertainty in outflow based on a triangular distribution with a minimum and maximum value provided)
- Stage-Discharge (stage in the channel with estimated error in feet)
- Stage-Damage (for each damage category, with mean and standard deviation using a normal distribution)
- Levee Failure Probability (based on two points Probable Non-Failure (PNP) and Probable Failure Points (PFP)

Economic damage inputs to the HEC-FDA model were initially analyzed by category and by reach using Excel with @RISK at each flood plain mapping determination (10-, 25-, 50-, 75-, 100-, 250- and 500-year) to develop an overall "stage-damage" function by category and by reach with error for the HEC-FDA model. The @RISK results and the corresponding frequency damage functions are described in the economic technical appendix to the feasibility report.

Expected flood damages were estimated for the following categories:

- Residential Inundation Damages to Structures and Contents
- Residential Clean-up Costs
- Emergency Costs
- Nonresidential Inundation Damages
- Nonresidential Clean-up Costs
- Traffic Delays
- Road Damages
- Sedro Woolley Wastewater Treatment Plant Damages
- Agricultural Damages

The category with the greatest expected annual damages was damage to structures and contents. Tables 5-8 and 5-9 show damages by event for residential and non residential structures/contents.

Table 5-8 - Total Residential Inundation Damages by Event

Flood Event	Structures	Structure Damage (in $1,000's)	Content Damage (in $1,000's)	Total Damage (in $1,000's)
10-year	2,091	49,888	28,306	78,194
25-year	5,839	172,237	96,429	268,666
50-year	7,635	254,837	141,204	396,040
75-year	8,495	308,612	169,907	478,519
100-year	9,345	369,007	202,083	571,089
250-year	10,812	515,957	278,816	794,773
500-year	11,841	681,033	363,462	1,044,495

Table 5-9 - Total Nonresidential Inundation Damages by Event (in $1,000's)

Flood Event	Inundated Structures	Structure Damage	Content Damage	Total
10-year	239	48,331	40,670	89,001
25-year	682	107,410	103,371	210,781
50-year	840	134,086	135,507	269,594
75-year	997	146,645	153,028	299,672
100-year	1,032	161,934	172,234	334,169
250-year	1,149	194,529	215,825	410,354
500-year	1,274	242,278	281,591	523,869

1.1.1.26 HEC-FDA Model Results

Residential, non-residential, and agricultural damages by event frequency were correlated to stage and entered into the HEC-FDA model by reach. Losses to the WWTP, traffic delays and road damages were also linked to stage and entered into the model. The HEC-FDA model processed this data through its random flood generation routine for the derivation of expected annual damages and project performance levels. The overall results of this modeling are presented in Table 5-10. Expected annual damage from the model is estimated at $77.3 million.

Table 5-10 - HEC-FDA Expected Annual Damages by Reach

Expected Annual Damage for the Without Project Condition[1]
(Damage in $1,000's)
(Analysis is based upon 5.375% discount rate, 2004 price level, and 50-year period of analysis)

	Damage Categories										Total
	Residential			**Public Assist-ance**	**TRA**	**Non-Residential**			**Agricult-ural Damages**	**Traffic Delays**	
	Structure	**Content**	**Cleanup**			**Structure**	**Content**	**Cleanup**			
Reach 1	11,296	6,249	1,885	1,859	547	7,860	7,760	1,141	864	2,296	41,757
Reach 2	3,674	2,018	548	538	160	112	95	18	1,236	0	8,399
Reach 3	40	23	10	12	3	9	7	1	25	0	130
Reach 4	4,511	2,467	662	667	196	3,081	3,466	777	127	0	15,954
Reach 5[1]	21	11	2	2	1	25	28	4	1	0	95
Reach 6	1,671	915	249	251	74	106	117	21	406	0	3,810
Reach 7	624	359	168	165	48	541	457	118	11	0	2,491
Reach 8[2]	466	252	59	52	15	72	15	3	6	2	942
Reach 9	349	196	47	38	11	34	31	0	96	25	827
Reach 10	615	290	102	1414	42	52	43	3	55	0	2,616
Road Damages											278
TOTAL	**23,267**	**12,780**	**3,732**	**4,998**	**1,097**	**11,892**	**12,019**	**2,086**	**2,827**	**2,323**	**77,299**

1 – Results shown in the table are derived using the 2004 H&H data and economic modeling. Subsequent to completion of economic modeling an error was found in input data for Reach 5, which underestimes Reach 5 total annual damages by approximately $100,000. Revisions to the modeling of expected damages in Reach 5 will be completed during the next iteration of modeling revisions following completion of revised H&H, Geotechnical, and Economic studies.

2 --[*]For the Sedro Woolley Waste Water Treatment Plant, all damages (to include structure/content/processing functions) are listed in Reach 8 as non-residential structure damage.

HEC-FDA computed damages by integrating discharge-probability, stage-discharge, stage-damage and levee failure relationships with uncertainty. For many reaches, levee failure in the form of probable failure and probable non-failure points (PFP and PNP) in the model affects the non-damaging frequency. The Monte Carlo simulation rans up to 500,000 iterations creating a range of expected values based on the hydrologic, hydraulic, geo-technical and economic relationships. The model aggregated these relationships creating a distribution of expected annual damages with the mean values by reach and category displayed in Table 5-10. Further studies involving with project conditions and alternative analysis, HEC-FDA will provide probability distributions for benefits and address residual risk issues.

In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and conditional non-exceedance probability by events. Project performance for each impact area is displayed in Table 5-11.

Table 5-11 - Project Performance by Damage Reach for the Without Project Condition

<table>
<tr><th colspan="12">Without Project Base Year Performance Target Criteria
Event Exceedance Probability = 0.01
Residual Damage = 5.00%</th></tr>
<tr><th rowspan="2">Reach</th><th colspan="2">Annual Exceedance Probability</th><th colspan="3">Long-Term Risk (years)</th><th colspan="6">Conditional Non-Exceedance Probability by Events</th></tr>
<tr><th>Median</th><th>Expected</th><th>10</th><th>25</th><th>50</th><th>10%</th><th>4%</th><th>2%</th><th>1%</th><th>.4%</th><th>.2%</th></tr>
<tr><td>Reach 1</td><td>0.151</td><td>0.154</td><td>81 %</td><td>98 %</td><td>100 %</td><td>38 %</td><td>5 %</td><td>1 %</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Reach 2</td><td>0.151</td><td>0.154</td><td>81 %</td><td>98 %</td><td>100 %</td><td>38 %</td><td>5 %</td><td>1 %</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Reach 3</td><td>0.072</td><td>0.087</td><td>60 %</td><td>90 %</td><td>99 %</td><td>82 %</td><td>70%</td><td>60 %</td><td>51 %</td><td>41%</td><td>32%</td></tr>
<tr><td>Reach 4</td><td>0.043</td><td>0.055</td><td>43 %</td><td>75 %</td><td>94 %</td><td>90 %</td><td>39 %</td><td>17 %</td><td>6 %</td><td>1 %</td><td>0</td></tr>
<tr><td>Reach 5*</td><td>0.002</td><td>0.003</td><td>3 %</td><td>8 %</td><td>16 %</td><td>100 %</td><td>100 %</td><td>100 %</td><td>97 %</td><td>70 %</td><td>39 %</td></tr>
<tr><td>Reach 6</td><td>0.307</td><td>0.312</td><td>98 %</td><td>100 %</td><td>100 %</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Reach 7</td><td>0.151</td><td>0.154</td><td>81 %</td><td>98 %</td><td>100 %</td><td>38 %</td><td>5 %</td><td>1 %</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Reach 8</td><td>0.007</td><td>0.008</td><td>8 %</td><td>18 %</td><td>33 %</td><td>100 %</td><td>100 %</td><td>97 %</td><td>74 %</td><td>19 %</td><td>5 %</td></tr>
<tr><td>Reach 9</td><td>0.081</td><td>0.081</td><td>57 %</td><td>88 %</td><td>99 %</td><td>72 %</td><td>12 %</td><td>2 %</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Reach 10</td><td>0.101</td><td>0.101</td><td>65 %</td><td>93 %</td><td>100 %</td><td>51 %</td><td>5 %</td><td>1 %</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="12">1 – Results shown in the table are derived using the 2004 H&H data and economic modeling. Subsequent to completion of economic modeling an error was found in input data for Reach 5. Revisions to the project performance statistics for Reach 5 will be completed during the next iteration of modeling revisions following completion of revised H&H, Geotechnical, and Economic studies.</td></tr>
</table>

The results of economic modeling of flood damages to date shows that under without project conditions, flooding is expected to present a serious and frequently occurring problem for the Skagit River basin. Some highlights identified through the current analysis include:

- Identification of over 14,200 structures that are at risk of flooding with a total property value (structure and content) of over $3.4 billion
- Estimation of potential total losses from a single flood event as great as $1.9 billion
- Estimation of expected annual damages to property and associated losses of over $72.2 million, with direct residential damages accounting for nearly 55% of the losses
- Estimation of $77.3 million in total annual damages associated with structures and contents, agriculture, traffic delay costs, and road damages/repairs

The high levels of damages in the study area are a function of the large aerial extent of the developed floodplain and the frequency of expected flooding. As Table 5-11 indicates, the risk of flooding at least once during a 25 year period exceeds 75% for all of the 10 study reaches except for Reaches 5 & 8[2]. Based on the annual exceedance probabilities, the highest chance of flooding in any given year is 1 in 3 for Reach 6.

Both the high expected annual damages and high probability of flooding indicate that the without project flood risk should be reduced. Without action, Skagit River flooding is expected to remain a frequently occurring problem with potentially devastating effects in the study area. This without project analysis will serve as a baseline for further alternative analysis during the next phase of study (with project analysis).

Environmental

Environmental & Biological Resources

1.1.1.27 Vegetation

Upper Basin

Approximately 90% of the Upper Skagit Basin is located within National Forest or National Park property. Of this area, 56% falls within Mount Baker National Forest and 31% falls within North Cascades National Park (NCNP). Large tracts of both old-growth and secondary-growth coniferous forests dominate the landscape in these areas. Four major forest types lie within the Upper Skagit Basin in NCNP: Western Hemlock Forest (0 to 2,000 feet in altitude), Pacific Silver Fir Forest (2,000 to 4,000), Mountain Hemlock Forest (4,000 to 5,500), and Subalpine forest (5,000 to 7,000+) (NPS 2008). The majority of all forest types are dominated by coniferous species. Species common to the higher elevations include mountain hemlock (*Tsuga mertensiana*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), noble fir (*Abies procera*), and Alaska yellow-cedar (*Palicourea croceoides*). Other common species that generally occur at lower elevations and along the rivers and tributaries are Western hemlock (*Tsuga heterophylla*), Western red cedar (*Thuja plicata*), Pacific silver fir (*Abies amabilis*), Douglas fir (*Pseudotsuga menziesii*), Western white pine (*Pinus monticola*), Sitka spruce (*Picea sitchensis*), and some deciduous species such as black cottonwood (*Populus trichocarpa*), alpine willow (*Salix petrophila*), cascade willow (*Salix cascadensis*), paper birch (*Betula papyrifera*), bigleaf maple (*Acer*

---

[2] **Subsequent to completion of economic modeling an error was found in input data for Reach 5, overestimating the level of protection in model results for Reaqch 5. Revisions to the project performance statistics for Reach 5 will be completed during the next iteration of modeling revisions following completion of revised H&H, Geotechnical, and Economic studies.**

macrophyllum), bitter cherry (*Prunus emarginata*), Sitka alder (*Alnus viridis* ssp. *sinuate*), red alder (*Alnus rubra*), and red osier dogwood (*Cornus sericea*) (NPS 2008).

The dense expanses of forests found in the Upper Skagit Basin are thought to be particularly susceptible to climate change. Current models have predicted warmer year-round temperatures, wetter winters, and dryer summers for the Pacific Northwest region. Such changes should increase rates of photosynthesis and forest growth (Rapp 2004). Increased woody vegetation and subsequent woody debris may lead to higher fire occurrence as the increased fuel load will readily cure during the longer, drier, and warmer summers. Existing forests will also likely be more frequently attacked by insects and diseases as warmer winters reduce the natural kill of insects and pathogens. In addition, a warming climate will also allow lower altitude species to expand their range upward in altitude and latitude allowing them to invade areas beyond their current distribution and displace existing species. It has been predicted that exotic species will also accelerate their range expansion into areas made newly available by the warming climate. The forest communities in the Upper Skagit Basin will likely change significantly over time.

The habitat found along the Skagit River in the northwestern portion of the Upper Skagit Basin consists almost entirely of conifer dominated forest intermixed with deciduous trees and shrubs. Further downstream, from Sedro Woolley to Marblemount, the riparian environment alternates from patches of agriculture, to urban landscapes with narrow greenbelts, to larger patches of primarily deciduous forests typical of the lowland floodplain. These deciduous forests contain trees such as black cottonwood and big leaf maple and shrubs such as willows and salmonberry (*Rubus spectabilis*). The three major tributaries of the Upper Skagit River; the Baker River (including Lake Shannon and Baker Lake), the Sauk River, and the Cascade River, are dominated by riparian areas lined with deciduous tree and shrubs. The frequency of agriculture and urbanization increases in a downstream direction, with the Lower Skagit Basin being dominated by agricultural and urban land uses.

Large woody debris (LWD) is common in the Skagit River upstream of Burlington (Pentec 2002). There is no transport of LWD from above the dams by either natural or human processes. LWD exists along the shoreline, both in water and as recruitable trees on the bank. Concentrations of LWD can be found at the upstream end of islands, such as those at river miles 35 and 58, or the entrance to side channels, such as at river mile 64.

Lower Basin

The Lower Skagit River Basin has had many landscape alterations in the past. On the lower mainstem, these alterations have resulted in the riparian reserve system to be fragmented, poorly connected, and inadequate in its ability to provide protection for habitats and refugia for sensitive aquatic species such as salmon. In many areas below Sedro Woolley, the establishment of dikes and levees has largely disconnected the river from its floodplain, reducing the once widely meandering river to a single, non-migratory channel. Floodplain habitats were significantly altered throughout the past 100 years through road building, bank hardening, hydropower operations, timber harvest in riparian zones and contributing upland areas, and rural development. The culmination of these alterations is seen in the reach spanning from the Skagit River Delta upstream 32 miles, where 62% of the mainstem channel edge has been hardened with riprap within about 200 feet of the channel's edge.

The Lower Skagit Basin currently encompasses a wide range of habitats which host an array of plant species. Western lowlands conifer-hardwood forest is widely distributed throughout the lowlands of the Cascades (Johnson and O'Neil 2001). This habitat is dominated by tree species such as Western hemlock and Douglas fir, with Western red cedar, Sitka spruce, red alder, and bigleaf maple also being common. This habitat also supports common understory plants such as salal (*Gaultheria shallon*), Oregon grape (*Mahonia aquifolium*), vine maple (*Acer circinatum*), Pacific rhododendron (*Rhododendron macrophyllum*), salmonberry, and trailing blackberry (<u>*Rubus ursinus*</u>) (Johnson and O'Neil 2001). Wetland and riparian zones are present in this area and are dominated by black cottonwood*,* willows (*Salix* sp.), and red alder. Various areas of grassland range across many elevations throughout the basin. Species common to these habitats include *Fescue* sp., *Poa* sp., *Carex* sp., and *Pinus* sp. (Johnson and O'Neil 2001). Agriculture, pasture, and mixed environments are widely distributed at low to mid-elevations in the broad river valley. These areas include many cover types of cultivated croplands that include ornamentals, vegetables, grains, orchards, berries, and nurseries. Introduced species such as Himalayan blackberry (*Rubus armeniacus*), reed canary grass (*Phalaris arundinacea*), Scotch broom (*Cytisus scoparius*), Japanese knotweed (*Polygonum cuspidatum*)*,* and butterfly bush (*Buddleja davidii*) are common throughout the lowlands.

Various measures of the health of the Lower Skagit River Basin have been used to assess its current status. A screening of the condition of riparian vegetation in floodplain habitats found significant impairment in most of the reaches surveyed (Beamer, *et al*. 2000). A majority of the present riparian zones below Sedro Woolley are either entirely devoid of trees or consist only of narrow strips of cottonwood and willow species. The reduced riparian area below Sedro Woolley reduces the likelihood of recruitment of LWD to the stream system or providing essential pieces for stable log jam formations. Even without further disturbance, this condition is unlikely to improve significantly in the near future.

Limited examples of high quality riparian habitat are found in the lower reaches. For example, Cottonwood Island, a 170 acre parcel at the confluence of the North and South Fork, is representative of a historic habitat type (prior to logging and development) and provides valuable habitat for a variety of forest birds and raptors, primarily buteos and eagles (Garrett, *et al*. 2006). Assessment of LWD in the lower Skagit River indicates that there is a lack of large wood in the system (Collins 2000). While LWD is generated in large quantities in the Upper Skagit Basin, there are few areas in the Lower River where the LWD can become permanently or semi-permanently deposited in or along the bed and banks. There are some localized areas of low velocity, such as Freshwater Slough, where LWD collects.

1.1.1.28 Wildlife

Upper Basin

The Upper Skagit Basin and in particular, NCNP hosts one of the greatest diversity of wildlife in the United States. The National Park protection designated to this area has perpetuated its ecosystem allowing many wildlife species to thrive to this day. Many species of amphibians, reptiles, fish, birds, and mammals are all common in this area. Large mammals found in the Upper Skagit Basin include moose (*Alces alces*), elk (*Cervus elaphus*), black-tailed mule deer (*Odocoileus hemionus*), black bear (*Ursus americanus*), mountain lion (*Puma concolor*), coyote (*Canis latrans*), mountain goat (*Oreamnos americanus*), and wolverine (*Gulo gulo*). Federally listed ESA species; grizzly bear (*Ursus arctos*), gray wolf (*Canis lupus*), and Canada lynx (*Lynx canadensis*) are also known to inhabit the area (see "Threatened and Endangered Species" for more details). Other mammal species such as river otter (*Lontra canadensis*), American beaver (*Castor canadensis*), northern raccoon (*Procyon lotor*), American marten (*Martes Americana*), and American mink (*Neovison vison*) are also found in the Upper Skagit Basin. Common small mammals are Townsend's chipmunk (*Tamias townsendii*), trowbridge shrew (*Sorex trowbridgii*), deer mouse (*Peromyscus maniculatus*), snowshoe hare (*Lepus americanus*), Douglas squirrel (*Tamiasciurus douglasii*), and a variety of bat species.

Birds are a significant component of biological diversity within the Upper Skagit Basin ecosystem. Over 200 species in 38 families can be found in NCNP alone. Two species; marbled murrelet (*Brachyramphus marmoratus*) and northern spotted owl (*Strix occidentalis caurina* are ESA listed species (see "Threatened and Endangered Species" for more details). The rivers, lakes, and streams of the Upper Skagit Basin attract breeding, migrating, and wintering birds. Clear, fast-flowing rivers and streams in the area host breeding populations of Harlequin ducks (*Histrionicus histrionicus*). The Skagit River attracts one of the largest wintering concentrations of bald eagles (*Haliaeetus leucocephalus*) in the continental United States. In this region, the bald eagle wintering season spans from mid-December to late January. Each year, around 600 eagles are drawn to the area by the large numbers of spawned out salmon that are common to the Upper Skagit Basin (Skagit River Bald Eagle Awareness Team 2006). Though most of the area eagles are migrants, resident bald eagles do occur in the area. Nesting in the Upper Skagit Basin typically occurs between early January and mid-August.

Many species including raptors that breed further north migrate through this area in spring and fall. Over half of the species breeding in the Upper Skagit Basin are migratory. Hummingbirds, flycatchers, vireos, swallows, thrushes, warblers, tanagers, and grosbeaks are among the species that return annually in spring. From May through July species such as olive-sided flycatcher (*Contopus cooperi*), warbling vireo (*Vireo gilvus*), Swainson's thrush (*Catharus ustulatus*), Wilson's warbler (*Wilsonia pusilla*), and Western tanager (*Piranga ludoviciana*) all arrive to breed. In August and September, these species begin their migrations south. Federally listed marbled murrelets and Northern spotted owls also utilize the forests of the Upper Skagit Basin (see "Threatened and Endangered Species" for more details).

Various reptiles and amphibians reside in the Upper Skagit Basin. Common species include Western terrestrial garter snake (*Thamnophis elegans elegans*), common garter snake (*Thamnophis sirtalis*), Northern alligator lizard (*Elgaria coerulea*), Cascade frog (*Rana cascadae*), Oregon spotted frog (*Rana Pretiosa*) (an ESA Candidate Species), Northern red-legged frog (*Rana aurora*), Pacific chorus frog (*Pseudacris regilla*), tailed frog (*Ascaphus truei*), Western toad (*Bufo boreas*), Northwestern salamander (*Ambystoma gracile*), and Northern rough-skinned newt (*Taricha granulosa*).

Climate change may lead to a much altered wildlife species assemblage found in the Upper Skagit Basin. Changes seen in vegetation communities due to changes in precipitation, temperature, pest and forest fire regimes will affect wildlife demographics. For example, warming streams could decrease already declining anadromous fish stocks and amphibians found in the area.

Lower Basin

The Skagit River Delta area is considered critical wildlife habitat for many species. It is particularly important as a waterfowl wintering area due to the mild winter climate and the presence of habitats such as expansive freshwater marshes, saltwater marshes, and intertidal flats. The many dikes or levees along its numerous sloughs have created extensive upland areas for agriculture. Various grain crops produced in areas such as Skagit Wildlife Recreation Area between Tom Moore Slough, Freshwater Slough, and the Hayton Reserve, are known to support waterfowl and other wildlife.

Few winter residents breed in the project area (in spring most leave for breeding areas further north). Wintering waterfowl common along the area sloughs in Skagit Bay and upland on farms during the peak months of October and November include ducks, geese, and swans. Dabbling ducks, such as mallard (*Anas platyrhynchos*), Northern pintail (*Anas acuta*), American widgeon (*Anas americana*), and green-winged teal (*Anas crecca*) are the most numerous, and utilize estuarine and agricultural areas. Snow geese (*Chen caerulescens*) are also present in the fall and winter months in the Skagit Delta. In past years, up to 50,000 have wintered in Skagit Flats. Swans (mainly trumpeters, but also more than a thousand tundra swans) visit the Skagit Estuary, feeding mainly on vegetation in shallows and agricultural fields. The trumpeter swan (*Cygnus buccinators*), once an endangered species, has increased in numbers in Skagit County from a 1963 population of 20 to several thousand today. The major wintering roosting area for this species is the Nookachamps Creek drainage (DeBays Slough and Judy Reservoir). Freshwater riparian habitat is important for waterfowl. The numerous sloughs adjacent to Skagit Bay are highly productive for mallards and wood ducks (*Aix sponsa*). Tom Moore Slough, near Milltown, provides productive habitat for waterfowl.

Wading birds, such as great blue heron (*Ardea herodias*), utilize the estuary areas year round. Shorebirds use flooded agricultural fields and estuaries mainly during migration and in winter. Mainly dunlin (*Calidris alpine*) and black-bellied plover (*Pluvialis squatarola*) winter in the Skagit delta. Several species of birds of prey are found in the project area including bald eagle (*Halieaeetus leucocephalus*), red-tailed hawk (*Buteo jamaicensis*), rough-legged hawk (winter only) (*Buteo lagopus*), Northern harrier (*Circus cyaneus*), gyrfalcon (winter only) (*Falco rusticolus*), peregrine falcon (*Falco peregrinus*), merlin (*Falco columbarius*), Coopers hawk (*Accipiter cooperii*), sharp-shinned hawk (*Accipiter striatus*), and osprey (*Pandion haliaetus*). The Skagit Delta provides habitat for one of the largest wintering populations of raptors in the contiguous United States. Bald eagles are also common in the Lower Skagit Basin along the Skagit River and its tributaries.

Large upland mammals such as black-tailed mule deer, can be found on Hart Island and are occasional visitors to the estuary, although this type of habitat is not favored by this species. The abundance of small mammals in the Skagit Delta accounts for the presence of raptors in the area. Semi aquatic mammals such as muskrat (*Ondatra zibethicus*), river otter, mink, and beaver inhabit the sloughs. In addition, nutria (*Myocaster coypus*), a large, destructive, semi-aquatic, non-native rodent have been confirmed to be present in the Skagit Valley. Nutria cause severe damage to native wildlife habitat and dikes due to their indiscriminate consumption of vegetation and burrowing techniques.

1.1.1.29 Fish

Anadromous species, which are common to the Skagit River, tend to move through both the Lower and Upper Skagit Basin en route to spawn. Because these fish can be found in either basin, they will be discussed in a single section that includes both of these areas. A list of these fish is available in Table 5-12. Fish that are only found in one subbasin will also be discussed below.

Table 5-12: Summary Table of Salmonids Found in the Lower and Upper Skagit Basins
(WDFW and WWTIT, 2003 draft; SWC 2005)

Stock	Origin	Production Type	Stock Status
Chinook – *Oncorhynchus tshawytscha*			
Samish/MS Nooksack	Non-native	Composite	Unknown
Upper Skagit Mainstem/Tribs	Native	Wild	Depressed
Lower Skagit Mainstem/Tribs	Native	Wild	Depressed
Lower Sauk	Native	Wild	Depressed
Upper Sauk	Native	Wild	Depressed
Suiattle	Native	Wild	Healthy
Upper Cascade	Native	Wild	Depressed
Coho – *Oncorhynchus kisutch*			
Samish	Mixed	Wild	Healthy
North Puget Sound Tribs	Native	Wild	Unknown
Skagit	Native	Composite	Healthy
Baker	Mixed	Composite	Healthy
Chum-Fall – *Oncorhynchus keta*			
Mainstem Skagit	Native	Wild	Healthy
Lower Skagit Tribs	Native	Unknown	Unknown
Sauk	Native	Wild	Healthy
Samish/Indpendent	Mixed	Composite	Healthy
Pink – *Oncorhynchus gorbuscha*			
Skagit	Native	Wild	Healthy
Sockeye – *Oncorhynchus nerka*			
Baker	Native	Cultured	Healthy
Steelhead-Summer – *Oncorhynchus mykiss*			
Finney Creek	Native	Wild	Unknown
Sauk	Native	Wild	Unknown
Cascade	Native	Wild	Unknown
Steelhead-Winter – *Oncorhynchus mykiss*			
Samish	Native	Wild	Healthy
Mainstem Skagit/Tribs	Native	Wild	Depressed
Sauk	Native	Wild	Unknown
Cascade	Native	Wild	Unknown

Most of the historic estuarine habitat was lost after diking isolated these areas from riverine and tidal processes. Further upstream, the waters of the Skagit River became degraded by runoff from the extensive logging operations in the headwaters. The installation of dams along the length of the Skagit further degraded the ecosystem.

Many beaver ponds, side channels, and sloughs once used by salmon have been disconnected from the main river channel as a result of diking and other agricultural practices and bank revetments. From 1860 to 1951, side channel slough habitat decreased by approximately 90% in the Skagit delta (Collins 2000). The Skagit basin lost approximately 45% of the historic side channel habitat (424,200 m^2) that provided critical rearing and refuge functions in the floodplain (Beechie, *et al*. 1994). The Skagit basin has lost approximately 72% of historic estuarine delta habitat, including a loss of 68% of estuarine emergent habitat, 66% of transitional estuarine forested habitat, and 84% of riverine tidal habitat (Beamer, *et al*. 2002a; Collins and Montgomery 2001). The Skagit delta has lost approximately 75% of its distributary channel habitat (Beechie, *et al*. 2001). A reduction in the number of side channels and sloughs, changes and reductions in the quality of riparian vegetation, and a reduction in the number of high quality stream channel pools significantly reduces the amount of available refugia resulting in not properly functioning conditions.

The Skagit River and the Skagit Estuary are critically important to all five species of Pacific salmon as well as steelhead and sea-run cutthroat. There are numerous runs that utilize both the mainstem Skagit and several of its tributaries, most of which spawn in the reaches above Sedro Woolley. The Skagit River and its tributaries also host the largest population of Puget Sound bull trout in Puget Sound Basin (Conner, Seattle City Light, pers. comm.). The lower reaches of the Skagit River serves as a transportation route for spawning adults and provides a rearing environment for juvenile anadromous species during their outmigration to the sea. The upper reaches of the Skagit River from Sedro Woolley up to Gorges dam, the Sauk River, the Cascade River, Lake Shannon and Baker Lake along with other upper tributaries compromise the majority of the spawning habitat. In these more natural upper sections of the river, suitable habitat features are still available for spawning and rearing, however the historic loss of tidal wetland and channel habitat from the Lower Basin has been identified as one of the most significant limiting factors in the recovery of Skagit Chinook (SWC 2005; WCC 2003). Research by the Skagit River System Cooperative and others has shown that the reduced amount of estuarine habitat is likely limiting the production of Chinook (Beamer, *et al*. 2003; Beamer, *et al.* 2002; Beamer, *et al*. 2000; Congleton, *et al*. 1981). Less than 27% of estuarine habitat remains (SWC 2004; WCC 2003), with the greatest losses occurring in riverine tidal habitat (less than 16% remains). Most of the historic estuarine habitat was lost after diking isolated these areas from natural occurring riverine and tidal processes

In 1992, seven populations of steelhead were described in the Skagit Basin; four populations of winter steelhead and three populations of summer steelhead; all are listed as being of native origin and with wild production. The winter steelhead population declined from a healthy status in the 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI), to a depressed status in the 2003 Washington State Salmonid Stock Inventory (SaSI) (WDFW and WWTIT 2003).

Very little spawning occurs in the lower reaches of the Skagit River, although documented Chinook, pink, and mainstem steelhead spawning areas fall within the lower portions of the watershed (WDFW 2003). Coho spawning also occurs in the Carpenter and Fisher Creek drainages and in Nookachamps Creek. In the more natural upper sections of the River, suitable habitat features are available for spawning and rearing. Seiler, *et al*. (1999) found that egg-to-migrant survival rates were highly correlated to flow.

With effects from climate change becoming more apparent (see the discussion on climate), it is thought that future pressures on salmonids in the Skagit Basin will be severe. Skagit River salmonids have already experienced a variety of pressures caused by many changes such as; diking, insufficient riparian vegetation and LWD, and floodplain development. The combination of these existing pressures and warmer wetter winters and hotter dryer summers could combine and lead to elevated summer and early fall water temperatures due to a lack of snow and glacial melt. Evidence suggests increased water temperatures may be intolerable to salmonids. Bull trout populations in the Skagit River system would be particularly affected since they require water no warmer than 9˚C for spawning and no warmer than 12˚C for rearing.

Predicted sea level rise would cause the freshwater and brackish marshes to retreat landward due to saltwater intrusion, forcing these marshes into an area already reduced by extensive development that has already occurred in the floodplain. This further reduction of brackish habitat that is required for smoltification and acclimation to changes in salinity, is estimated to range from a 77% to 97% total loss (Glick, *et.al.* 2007), further limiting the production of anadromous fish in the Skagit Basin.

Several resident fish species are also found in the Skagit River system. While these species are all found in the Lower Skagit Basin, some can be also found in the Upper Basin. These species include rainbow trout (*Oncorhynchus mykiss*), kokanee (*Oncorhynchus nerka*), mountain whitefish (*Prosopium williamsoni*), Salish sucker (*Catostomus catostomus*), largescale sucker (*Catostomus macrocheilus*), three-spine stickleback (*Gasterosteus aculeatus*), brown trout (*Salmo trutta*), brook tout *(Salvelinus fontinalis*), lake trout (*Salvelinus namaycush*), Western brook lamprey (*Lampetra richardsoni*), Pacific lamprey (*Lampetra tridentata*), torrent sculpin (*Cottus rhotheus*), prickly sculpin (*Cottus asper*), and coast range sculpin (*Cottus aleuticus*).

1.1.1.30 Threatened and Endangered Species

Several federally listed threatened and endangered species occur in both the Lower and Upper Skagit Basins (Table 5-13). Because most of these species occur in both basins, each species will be discussed in its own section.

Table 5-13: Listed Species Potentially Occurring in the Project Area (WDFW 2008)

SPECIES	SCIENTIFIC NAME	STATUS
Puget Sound Chinook Salmon	*Oncorhynchus tshawytscha*	Threatened
Puget Sound/Strait of Georgia Coho Salmon	*Oncorhynchus kisutch*	Candidate
Puget Sound Steelhead	*Oncorhynchus mykiss*	Threatened
Coastal/Puget Sound Bull Trout	*Salvelinus confluentus*	Threatened
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened
Northern Spotted Owl	*Strix occidentalis*	Threatened
Grizzly Bear	*Ursus arctos*	Threatened
Canada Lynx	*Lynx canadensis*	Threatened
Gray Wolf	*Canis lupus*	Threatened

Puget Sound Chinook Salmon

Six stocks of Puget Sound Chinook salmon occur in the Upper Skagit with most being ocean type. The lower Skagit Chinook population was classified as depressed in both the 1992 SaSI and the 2003 SaSI (WDFW and WWTIT 2003). Spawning occurs from early September to mid-November (WDFW and WWTIT, 2003) in the Upper Skagit Basin. Lower Skagit Chinook spawn in the mainstem Skagit River and in tributaries downstream of the Sauk River confluence; most of the spawning occurs in the mainstem Skagit River between Sedro Woolley and the Sauk River (WDFW and WWTIT 2003). Upper Skagit Chinook spawn from mid-August through October in the mainstem Skagit River and in tributaries upstream of the Sauk confluence. The lower Sauk Chinook population spawns in the Sauk River from the mouth upstream to the Darrington Bridge at river mile 21.2. Its status was classified as depressed in both the 1992 and 2003 population inventories (WDFW and WWTIT,2003). The Lower Sauk population spawns earlier, beginning in late August and continuing to early October, than the mainstem Skagit populations. Upper Sauk Chinook spawn upstream of the Darrington Bridge and into the North and South Forks of the Sauk River. The status changed from healthy in 1992, to depressed in 2003 (WDFW and WWTIT 2003). Spawning occurs from late July through early September. Suiattle Chinook have the same early spawn timing as upper Sauk Chinook. The Suiattle population spawns in the mainstem Suiattle River, and in Big, Tenas, Straight, Circle, Buck, Lime, Downey, Sulphur, and Milk Creeks. Its population status changed from depressed in 1992, to healthy in 2003. Upper Cascade Chinook spawn in the mainstem Cascade River above RM 7.8, in the lower reaches of the North and South Forks of the Cascade River, and in Marble, Found, Kindy, and Sonny Boy Creeks. Its population status changed from unknown in 1992, to depressed in 2003. Spawning occurs from late July through early September.

Critical habitat has been designated for the entire Lower Skagit and Upper Skagit River. Critical habitat primary constituent elements (PCEs) include freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. Additional PCEs were developed for estuarine and marine habitats.

Coastal/Puget Sound Bull Trout

The Skagit River supports the largest natural population of bull trout/Dolly Varden in Puget Sound. Of this population, Lower Skagit bull trout were identified as a distinct stock based on their geographic location; an area which includes all of the Skagit River and its tributaries located below the Gorge Dam, excluding the Baker River (WDFW 1998). Anadromous, fluvial, adfluvial, and resident life history forms are all found in the Skagit River system, at times spawning at the same time and place. Spawning usually takes place during September and October, and occurs in upriver areas that are less than 8°C (WDFW 1998). Bull trout are apex predators that locate where prey is abundant and will follow prey such as migrating juvenile salmon.

Based on sampling by the Skagit River System Cooperative (Beamer and Henderson, 2004), bull trout were found to use delta blind tidal channels but did not directly use smaller and shallower channels or channels more distant from river distributaries. Trends in annual abundance remained constant during the study. The presence of bull trout varies significantly throughout the year, with the primary period from April through August, with a peak in June. Bull trout in the Skagit are known to migrate to both Puget Sound and other river systems including the Stillaguamish and Snohomish, in search of food. Although the majority of these migrants return to the Skagit to spawn (Geotz, per. comm. 2008).

Bull trout are also present in Skagit Bay; however, their presence in shallow intertidal habitat was very low compared to the deeper intertidal-subtidal fringe. Bull trout are present in the deeper intertidal-subtidal habitats year round. Peak abundance in the bay occurs in May or June, with recent data showing a second peak in fall.

Critical habitat was designated for the entire Lower Skagit and Upper Skagit River to the portions of Ross Lake and its tributaries that lie within the boundaries of the United States. Critical habitat PCEs determined essential to the conservation of bull trout include water temperatures between 36°F and 59°F, complex stream channels, appropriate substrate for spawning and rearing success, a natural hydrograph, sufficient water quality and quantity including subsurface connectivity, migratory corridors, abundant food base, and lack of nonnative predatory or competitive species.

Puget Sound Steelhead

All seven stocks of Skagit River steelhead are found in both the Upper and Lower Skagit Basins. All are listed as being of native origin and with wild production and are considered to be distinct based on geographic separation. Steelhead in the Skagit River system spawn in both the mainstem and tributaries from the anadromous zones to the headwaters. Summer steelhead run through the Skagit system from May to October and winter steelhead run from November to April. Although there is some fishing pressure on wild steelhead in the Skagit River system, the majority of fishing is for hatchery fish that are planted in the river annually. Of the seven wild stocks of steelhead in the Skagit system five of them have an unknown stock status. The remaining stocks; winter run of the mainstem Skagit River and Samish winter run have stock statuses of healthy and depressed, respectively (WWTIT 2003). Critical habitat has not yet been designated for Puget Sound Steelhead though it is pending.

Skagit mainstem winter steelhead spawning takes place in the mainstem Skagit from just above Mount Vernon up to Gorges Dam and all the major tributaries in between including the Nookachamps, Sauk and Cascade Rivers, and Lake Shannon and Baker Lake. Spawning occurs from early March to early June. Mainstem Skagit winter steelhead stock status has gone from healthy in 1992 to depressed in 2002 (WDFW 1994; WDFW 2003). Finney Creek summer steelhead are thought to spawn in Finney Creek up to the falls at river mile 11.7, however, precise locations are unknown. Spawn timing and stock status are also unknown. Sauk summer run steelhead spawn in the North Fork and South Fork of the Sauk River to just below the forks. Spawning occurs from mid-April to early June, and stock status in unknown. Sauk winter run steelhead takes place in the Sauk, Suiattle, and Whitechuck rivers and their tributaries. Spawn time occurs from mid-March to mid-July and the stock status in unknown Cascade summer run steelhead spawning is thought to take place in the upper reaches of the Cascade river and its forks, however exact locations are unknown. Spawning occurs from mid-January to early May, and stock status is unknown. Cascade winter run steelhead spawning locations are unknown, as is the spawning time (although it is thought to occur in early March through late June.

Puget Sound/Strait of Georgia Coho Salmon

Puget Sound/Strait of Georgia coho evolutionary significant unit (ESU) includes coho that spawn throughout the Skagit system in smaller tributaries with good cover. Spawning typically occurs from October through late February. Juveniles rear for approximately one year in slower water habitats before out-migrating in the spring and early summer of their second year (WDFW 1994).

Marbled Murrelet

Murrelets inhabit shallow marine waters and nest in mature old-growth forests. Critical habitat has been designated to include upland forested stands containing large trees (greater than 32 inches) in diameter with potential platforms for nesting (greater than 33 feet) and the surrounding forested areas within 0.5 mile of these stands with a canopy height of at least 1/2 the site-potential height (USFWS 1996). All nest locations in Washington have been located in old-growth trees that were greater than 32 inches in diameter at breast height (dbh) (Ralph, *et al*. 1995). Nest stand characteristics generally include a second story of the forest canopy that reaches or exceeds the height of the nest limb, thereby providing a protective enclosure surrounding the nest site. A single, large, closed-crowned tree, which provides its own protective cover over the nest site may also be used by murrelets (Ralph, *et al*. 1995). Large, moss-covered limbs (greater than 7 inches diameter) in tall trees are utilized for egg-laying. Marbled murrelet nests have been located in stands as small as approximately seven acres (Hamer and Nelson 1995) and are generally within 50 miles of marine waters. In Washington, marbled murrelet abundance was found to be highest in areas where old-growth/mature forest comprised more than 30 percent of the landscape. Murrelet nesting habitat is characteristic of the forested mountain landscape in the upper Skagit basin.

Critical habitat for the marbled murrelet has been designated throughout the Upper Skagit basin (USFWS, 2006). US Forest Service surveys indicate that the northern half of the Mount Baker-Snoqualmie National Forest accounts for 50 percent of the nesting habitat and 85 percent of the detections in the entire forest (USFS 2002). Numerous confirmed occurrences of marbled murrelets have occurred over the past two decades in both Whatcom and Skagit counties (WDFW 2008).

Northern Spotted Owl

Spotted owls can be found throughout the west slope of the Washington Cascades below elevations of 4,200 feet. Preferred owl habitat is composed of closed-canopy coniferous forests with multi-layered, multi-species canopies dominated by mature and/or old-growth trees (USFWS 2008). Habitat characteristics include moderate to high canopy closure (60-80%); large (greater than 30-inch dbh) overstory trees; substantial amounts of standing snags, in-stand decadence, and coarse woody debris of various sizes and decay classes scattered on the forest floor (Gore, *et al*. 1987; Thomas, *et al*. 1990). Critical habitat is characterized as large continuous blocks of coniferous/mixed-hardwood forests that contained one or more of the primary constituent elements (primarily nesting and roosting, but also foraging and dispersal). It is usually equivalent to structures of Douglas fir stands 80 or more years of age (USFWS 1992).

Designated critical habitat for the northern spotted owl is found throughout the upper Skagit basin. Numerous confirmed occurrences of the spotted owl over the past two decades are documented in both Whatcom and Skagit counties (WDFW, 2008).

Grizzly Bear

Estimates according to Ingles (1974), there were approximately 10 grizzlies in Washington State with these few remaining in remote areas of the North Cascades. WDFW priority habitat lists both Whatcom and Skagit (both of which encompass the upper Skagit basin) along with all their neighboring habitats as potential grizzly bear habitat (WDFW 2008). Recent estimates of grizzly bear population in the North Cascades range from 12 to 50 individuals (Almack, *et. al*., 1993; MacCracken and O'Laughlin 1998). According to the National Park Service approximately 10 - 20 grizzly bears live within Washington's North Cascades Grizzly Bear Recovery Area, *roughly* defined as the area between Interstate 90 in the south, up the Columbia and Okanogan Rivers on the east to the international boundary; then back south generally along the Mount Baker-Snoqualmie National Forest's western boundary (which is the western portion of both Skagit and Whatcom counties beginning just east of the towns of Lyman and Glacier). All five of the major dams on the Skagit River system fall within this recovery area. In British Columbia's North Cascades Grizzly Bear Population Unit (bounded by the Trans-Canada Highway, Highways 8, 5A and 3 and the international border), the minimum population estimate is 17 grizzly bears (NPS 2008). However, it is difficult to get exact estimates of grizzly bears as their territories can be several hundred square miles and their behavior is secretive. A study using DNA analysis of fur snags via barbed wire and scent lures showed only one grizzly present at the snag sites over the course of three years in the North Cascades and suggested that natural recovery seemed unlikely (Romain-Bondi, *et.al*. 2004).

Grizzly bear sightings in the North Cascades Ecosystem are classified as categories 1-4, with class 1 being the most reliable (verified by a biologist, photograph, and/or carcass) and 4 being the least (a sighting initially reported as a grizzly but later confirmed to be another species). Between 1983 and 1991, there were 20 Class 1 sightings, 82 Class 2 sightings, and 102 Class 3 sightings. In 1996, a bear biologist saw a grizzly bear on the south side of Glacier Peak in the Glacier Peak Wilderness Area. This is the last recorded Class 1 observation (Grizzly Bear Outreach Project 2008). According to the WDFW priority habitat database confirmed grizzly bear occurrences have been reported numerous times around Ross Lake in the 1970's, 80's, and 90's. They have also been occurrences at Diablo Dam in 1983, 1987, 1992, and 1993. The database also reports single confirmed occurrences near the North Fork Sauk River, the Cascade River, Bacon Creek west of Baker Lake, and Ruby Creek near the Okanogan County border (WDFW 2008).

Gray Wolf

According to Ingles (1974), the gray wolf is present in a small area in the North Cascades, although rare, and in hard, cold winters they may come down to lower elevations for food. The northern part of the Upper Skagit Basin falls within this distribution. WDFW also confirms the presence of wolves in the North Cascades. They are regularly sighted in southern British Columbia just north of North Cascades National Park. WDFW lists both Whatcom and Skagit County (both of which encompass the Upper Skagit watershed) along with all their neighboring counties as priority habitat for wolves (WDFW 2008). The data base indicates many occurrences of gray wolves over the last two decades, many of which were within close proximity of Ross Lake. In 1991, wolves with pups were observed near Hozomeen at the north end of Ross Lake. Other confirmed occurrences in the watershed include Baker Lake in 1984 and 1992, the Sauk River in 1992, Suiattle River in 1989, and the mainstem Skagit near Briar and Copper Creeks in 1988 and 1992, respectively (WDFW 2008). Locations of other sightings in the North Cascades include McAlester Pass, Pasayten Wilderness and Twisp River drainage of the Okanogan National Forest, Glacier Peak Wilderness, and Stevens Pass (NPS 2008b). A more recent sighting of a grey wolf pair and pups, and howling surveys in July of 2008 have verified their presence in western Okanogon County just adjacent to Skagit and Whatcom counties (WDFW 2008).

Canada Lynx

Canada lynx require dry forests where lodgepole pine is the dominant tree species. These areas are more typical of the east slopes of the Cascades. Lynx are rarely found below elevations of 4,000 feet. In 2001, the population of Canada lynx in Washington State was estimated at fewer than 100 individuals (Stinson 2001). A small population of Canada lynx inhabits the Pasayten Wilderness east of Ross Lake in the Okanogan National Forest (National Park Service 2007). Canada lynx are not known or suspected in the Upper Cascade watershed (Stinson 2001). Critical habitat for Cananda lynx has been designated on the eastern slopes of the Cascades in Okanogon County- just east of Skagit and Whatcom counties (USFWS, 2008). However, the WDFW priority habitat and species list includes both Whatcom and Skagit counties as priority habitat for Canada lynx and there are several confirmed occurences most of which are along the easternmost portions of the two counties along the Okanogon County border. In 2000 there were confirmed Canada lynx occurrences on the west slopes of the Cascades near Devils Dome and Buckskin Ridge just four miles and seven miles east of Ross Lake, respectively (WDFW 2008). Numerous anecdotal reports of Canada lynx have occurred around Baker Lake and Mount Baker (USFWS 2001).

1.1.1.31 Wetlands and Other Waters of the U.S.

A wetland survey of the delta conducted by Shapiro and Associates for the Corps of Engineers in 1978 identified 3,450 acres of estuarine wetland, 120 acres of riverine wetland, and 3,150 acres of palustrine wetlands adjacent to the Skagit River in the delta. This study did not attempt to identify wetlands that were converted to agricultural uses.

Prior to 1879, a log jam nearly one mile in length came close to covering the entire river near the location of Mt. Vernon. During freshets, this jam obstructed the free flow of water and obstructed the passage of all logs and drift. This blockage prevented the free flow of flood waters, thus reducing flooding in the delta area. Consequently, flooding primarily occurred in the areas known as Olympia and Beaver Marsh, located to the west of the Skagit River between the present locations of the town of Avon and Padilla Bay (Corps 1897).

In 1881, Robert Habersham, an Assistant Engineer for the Corps, wrote that while making an examination of the lowlands lying between the Skagit and Samish Rivers in 1872, he saw indications that the Skagit flowed into Padilla Bay at one time, 12 miles north of the present mouth of Steamboat Slough. The old channel was easily traced, traversed by numerous beaver dams. Habersham felt that the beaver dams caused the channel to change (Corps 1881). In 1924, the U.S. Geological Service (USGS) confirmed this observation concluding that Padilla Bay was once the mouth of the Skagit River. When the channel changed, the old outlet was filled with alluvial mud (C.H., personal communication).

National Wetland Inventory maps have identified pockets of wetland areas on both sides of the dikes in the Skagit delta. Despite this, the majority of the lowlands in the delta exhibit wetland characteristics. In most cases, the intensive agricultural practices on the land have caused these lands to be effectively drained and thus they can be designated as prior converted cropland (Kilcoyne, per. comm. 2006). Based on an inventory conducted in 1991, it is thought that there are approximately 76,188 acres of potential wetlands (land that could be wetland but has not been directly delineated) in Skagit County. Approximately 41% of this acreage is currently estuarine or marine wetland habitat.

A large expanse (~2,500 acres) of vegetated wetlands is present beyond the sea dikes at Fir Island (Shapiro, 1978). Beyond this marsh are approximately 6,600 acres of eelgrass beds (G. Hood, pers. comm., Skagit River System Cooperative 2008) and approximately 10,000 acres of unvegetated intertidal flats. Padilla Bay lies to the north of the project area. In historic times, floodwaters from the Skagit reached Padilla Bay on a regular basis; however, dikes constructed along the river now prevent Skagit River flows from reaching the bay. This change results in sedentary conditions being present within the bay, increasing the size of eelgrass beds. Padilla Bay now has approximately 8,000 acres of eelgrass, making it one of the largest eelgrass concentrations on the west coast of North America.

Sea level rise will likely shift the distribution of eelgrass beds, mudflats, and salt, brackish, and freshwater marshes landward. This shift will be restricted on the landward side due to the development that abuts the marshes leading to a likely overall decline in brackish and freshwater habitat. Most of the brackish marsh in Skagit Bay that is present today would be converted to salt marsh (Glick, *et.al*. 2007). It is speculated that eelgrass beds may benefit due to an increase in shallow saltwater habitat (Greg Hood, per. comm., Skagit River System Cooperative 2008).

Climate change, and the associated changes in precipitation and groundwater patterns, may result in large scale changes to wetland complexes and the functions they provide. Increased intensity of flood events may alter the sedimentation deposition and erosion patterns. Changes in precipitation patterns may alter groundwater recharge/discharge rates and locations, and reduced summer river flow may alter the vegetation communities and animal habitats in these wetlands. (Kusler 2005).

References

Almack J.A., W.L. Gaines, R.H. Naney, P.H. Morrison, J.R. Eby, G.F. Wooten, M.C. Snyder, S.H. Fitkin, and E.R. Garcia. 1993. North Cascades grizzly bear ecosystem evaluation: Final report. Interagency Grizzly Bear Committee, Denver, Colorado, USA.

Beamer, E., et al. 2000. Application of the Skagit Watershed Council's strategy river basin analysis of the Skagit and Samish Basin: Tools for salmon habitat restoration and protection. Working document prepared by the Habitat Restoration and Protection Committee of the Skagit Watershed Council. Mt. Vernon, Washington.

Beamer, E., R. Henderson, and K. Larsen. 2002. Evidence of an estuarine habitat constraint on the production of wild Skagit Chinook. Presentation at Western Division AFS Meeting in Spokane April 29-May 1, 2002. Skagit System Cooperative. La Conner, Washington.

Beamer, E., and R. Hendersen. 2004. Distribution, abundance, timing, size of anadromous bull trout in the Skagit River Delta and Skagit Bay. Skagit River System Cooperative. La Conner, Washington.

Beechie, T., E. Beamer, and L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management 14: 797-811.

Beechie, T.J., B.D. Collins, and G.R. Pess. 2001. Holocene and recent geomorphic processes, land use, and salmonid habitat in two North Puget Sound River Basins. *In:* Geomorphic Processes and Riverine Habitat (Dorava, J.M., D.R. Montgomery, B.B. Palcsak, F.A. Fitzpatrick, eds.). Water Science and Application Volume 4, pp.37-54.

Collins, B. 2000. Mid-19th century stream channels and wetlands interpreted from archival sources for three north Puget Sound estuaries. Prepared for: Skagit System Cooperative, Bullitt Foundation, Skagit Watershed Council. Prepared by: Brian Collins, University of Washington, Seattle, WA. Aug. 1, 2000.

Collins, B.D. and D.R. Montgomery. 2001. Importance of archival and process studies to characterizing pre-settlement riverine geomorphic processes and habitat in the Puget lowland. *In*: Geomorphic processes and riverine habitat (Dorava, J.M., D.R. Montgomery, B.B. Palcsak, and F.A. Fitzpatrick, eds.). Water Science and Application Volume 4, pp. 227-243.

Congleton, J.L., S.K. Davis, and S.R. Foley. 1981. Distribution, abundance and outmigration timing of chum and Chinook salmon fry in the Skagit salt marsh, pp. 153-163. *In*: Proceedings of the salmon and trout migratory behavior symposium (E.L. Brannon and E.O. Salo (eds.)). School of Fisheries, University of Washington, Seattle, Washington.

Garrett, J., B. Schuster, and D. Gleisner. 2006. Draft Skagit wildlife area management plan. Washington Department of Fish and Wildlife. Olympia, Washington.

Geotz, F., 2008. Personal communication with Chemine Jackels, U.S. Army Corps of Engineers, Seattle, Washington.

Glick, P.J. Clough, and B. Nunley. 2007. Sea-level Rise and Coastal Habitats in the Pacific Northwest: An Analysis for Puget Sound, Southwestern Washingotn, and Northwestern Oregon.

Gore, J., B. Mulder, and J. Bottorff. 1987. The northern spotted owl status review. Unpubl. rep., US Fish and Wildlife Service, Region 1, Portland, OR.

Grizzly Bear Outreach Project. 2008. Accessed online at: http://www.bearinfo.org

Hamer, T.E. and S.K. Nelson. 1995. Characteristics of Marbled Murrelet Nest Trees and Nesting Stands. Pages 69-82 in C.J. Ralph, G.L. Hunt, M. Raphael, and J.F. Piatt (Tech, eds.). Ecology and Conservation of the Marbled Murrelet. PSW-GTR-152. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Hood, G., Skagit River System Cooperative, 2008. Personal communication with Chemine Jackels, U.S. Army Corps of Engineers, Seattle, Washington.

Ingles, Lloyd. 1974. Mammals of the Pacific States. Stanford University Press, Stanford.

Johnson, D. and O'Neil T. 2001. Wildlife-Habitat Relationships in Oregon and Washington. OSU Press. Corvallis, OR.

Kilcoyne, K. 2006. Personal communication on 25 January with Michael Scuderi. NRCS, Mt. Vernon, Washington.

Kusler, J. 2005. Common Questions: Wetland, Climate Change and Carbon Sequestration. Association of State Wetland Managers, Berne, New York.

MacCracken, J.G. and O'Laughlin, J.. 1998. Recovery Policy on Grizzly Bears: An Analysis of Two Positions. *Wildlife Society Bulletin 26:899-907.*

National Park Service (NPS). 2007. 2007 Natural Notes: Threatened Species. http://www.nps.gov/noca/naturescience/upload/NaturalNotes_07page4.pdf

National Park Service. 2008. North Cascades National Park Service Complex: Grizzly bear research. Accessed online at: http://www.nps.gov/noca/naturescience/grizzly-bear-research.htm

National Park Service. 2008a. North Cascades National Park Tree List. Accessed online at: http://www.nps.gov/noca/naturescience/upload/treecheck.pdf

National Park Service. 2008b. http://www.nps.gov/archive/noca/wolf.htm

Pentec Environmental, 2002, geomorphic and Sediment Transport Study of Skagit River Flood Hazard Mitigation Project Skagit County, Washington, Phase 1 Interim Report, Prepared for USACE Seattle District, December 2002.

Ralph, C.J., G.L. Hunt, M.G. Raphael, and J.F. Piatt eds. 1995. Ecology and Conservation of the Marbled Murrelet. U.S. Forest Service, Pacific Southwest Research Station General Technical Report PSW-GTR-152. Albany, CA.

Rapp, V. 2004. Western Forests, Fires Risk and Climate Change. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Romain-Bondi, K.A., R.B. Wielgus, L. Waitts, W.F. Kasworm, M. Austin, and W. Wakkinen. 2004. Density and population size estimates for North Cascade grizzly bears using DNA hair-sampling techniques. *Biological Conservation*, 117: 417-428.

Seiler, D., L. Kishimoto, and S. Keuhauser. 1998. 1997 Skagit River wild 0+ Chinook production evaluation. Washington Department of Fish and Wildlife, Olympia, Washington. 57 pp.

Seiler, D., L. Kishimoto, and S. Neuhauser. 1999. Annual report: 1998 Skagit River wild 0+ Chinook production evaluation. Washington Department of Fish and Wildlife, Olympia, Washington.

Shapiro and Associates, Inc. 1978. Inventory of wetlands, Lower Skagit River. Report on file at U.S. Army Corps of Engineers, Seattle, Washington.

Skagit River Bald Eagle Awareness Team. 2006. Available at: http://www.skagiteagle.org/wildlife/eagle-count.html.

Skagit River Bald Eagle Awareness Team. 2006. Available at: http://www.skagiteagle.org/wildlife/eagle-count.html.

Skagit Watershed Council (SWC). 2005 Skagit Watershed Council Year 2005 strategic approach.

Stinson, D.W. 2001. *Washington state recovery plan for the lynx*. Washington Department of Fish and Wildlife. Olympia, USA.

Thomas, J.W., E.D. Forman, J.B. Lint, E.C. Meslow, B.B. Noon, and J. Verner. 1990. A conservation strategy for the northern spotted owl. Report of the interagency scientific committee to address the conservation of the northern spotted owl. Portland, OR.

U.S. Army Corps of Engineers (Corps). December 11, 1897. Report of Captain Harry Taylor.

U.S. Army Corps of Engineers (Corps). June 30, 1881. Report of Robert Habersham, Assistant. Engineer.

United States Fish and Wildlife Service (USFWS). 1992. Endangered and threatened wildlife and plants: Designation of critical habitat for the northern spotted owl. 57 FR 1796-1838.

United States Fish and Wildlife Service (USFWS). 1996. Endangered and threatened wildlife and plants; Final designation of critical habitat for the marbled mrrelet. 60 FR 26256-26320.

United States Fish and Wildlife Service (USFWS). 2001. Management of Canada Lynx in the Cascades Geographic Areas of Oregon and Washington. Accessed online at: http://www.peer.org/campaigns/whistleblower/lynx/April_10_01)FWS_whitepaper.pdf

United States Fish and Wildlife Service (USFWS). 2006. Endangered and threatened wildlife and plants; Designation of Critical Habitat for the Contiguous United States Distinct Population Segment of the Canada Lynx; Final Rule. 71 FR 66007-66061.

United States Fish and Wildlife Service. USFWS. 2008. Final Recovery Plan for the Northern Spotted Owl (Strix occidentalis caurina). US Fish and Wildlife Service. xii+142pp.

United States Forest Service (USFS). 2002. Baker River Watershed Analysis. Mount Baker-Snoqualmie National Forest, Pacific Northwest Region, Seattle, Washington.

UW Climate Impacts Group. 2008. Accessed online at: http://www.cses.washington.edu/db/pdf/moteetalslr579.pdf

Washington Conservation Commission (WCC). 2003. Salmon and steelhead habitat limiting factors Water Resource Inventory Areas 3 and 4, the Skagit and Samish Basins. Lacey, Washington.

Washington Department of Fish and Wildlife (WDFW) and Western Washington Treaty Indian Tribes (WWTIT). 1994. 1992 Washington State salmon and steelhead stock inventory; Appendix One, North Puget Sound. Washington Department of Fish and Wildlife. Olympia, Washington.

Washington Department of Fish and Wildlife (WDFW). 1998. Washington State salmonid stock inventory; bull trout/Dolly Varden. Olympia, Washington.

Washington Department of Fish and Wildlife(WDFW) and Western Washington Treaty Indian Tribes(WWTIT). 2003 draft. 2002 Washington State salmon and steelhead stock inventory, Olympia, Washington.

Washington Department of Fish and Wildlife (WDFW). 2008. Priority Habitat and Species Database. *(note: for any individual to obtain access to this database a request must be submitted to WDFW)*

Western Washington Fish and Wildlife Office 1 Rev. 11/5/08 ENDANGERED, THREATENED, PROPOSED, AND CANDIDATE SPECIES, CRITICAL HABITAT, AND SPECIES OF CONCERN IN WESTERN WASHINGTON http://www.fws.gov/westwafwo/pdf/species_list.pdf

PLAN FORMULATION

Problems and Opportunities

Major flooding has occurred in the Skagit River Basin. Because of its geographic location, the Skagit River Basin is subject to winter rain floods and an increase in discharge during spring due to snowmelt runoff. Rain-type floods usually occur in November or December, but may occur as early as October or as late as February. Antecedent precipitation serves to build up ground water reserves. Frequently, a light snow pack is then formed over most of the entire basin. A heavy rainfall accompanied by warm winds completes the sequence which produces major floods. The heavy rainfall and accompanying snowmelt result in a high rate of runoff, as the ground is already nearly saturated from earlier precipitation. Two or more crests may be experienced within a period of a week or two as a series of storms move across the basin from the west. The winter floods have a considerably higher magnitude than the average annual spring high water. Flood damages have been reduced in recent years with a well-maintained local levee and dike system on the Lower Skagit River, and a well organized and effective flood fighting effort. These floods have been under 30-year events. It is expected that floodfighting will not be able to stop larger hydrologic events and their is potential for devastating flooding throughout the valley.

Additionally, floodplain development and hydrologic modifications in the Skagit River Basin have resulted in ecosystem degradation. Construction of sea dikes, Skagit River levees and, agricultural drainage projects have converted the once broad Skagit River Delta tidal estuary into one of the most productive agricultural production areas in the Nation. However the floodplain developments have also had adverse impacts on native fish and wildlife including multiple salmonid species currently listed as threatened and endangered under the Endangered Species Act.

The following statements in Table 6-1 describe the Problems and Opportunities identified for the Skagit River Flood Damage Reduction and Ecosystem Restoration Feasibility Study.

Table 6-1. Problems and Opportunities

• The urban areas of the floodplain, principally portions of Hamilton, Mount Vernon, Burlington, and La Conner are at high risk of severe flooding.
• Rich and productive agricultural lands in the Skagit Valley are prone to severe flooding due to levee overtopping and failure.
• Major transportation corridors (including Interstate 5, State Route 20, and Burlington Northern-Santa Fe Railroad) and public infrastructure are also prone to severe flooding.
• Skagit River ecosystem structures, functions, and processes are degraded.
• The Skagit River basin has a number of separate Diking Districts that oversee levees providing at a maximum 35 year recurrence interval flood protection. There is an opportunity to provide the basin with an overall flood risk management system.
• Ecosystem functions and processes in the Skagit River and delta can be improved to benefit fish and wildlife, including listed salmonids.

Planning Objectives

Planning Objectives are statements that describe the desired results of a project in terms of solving stated problems and taking advantage of opportunities. Table 6-2 presents the planning objectives for this feasibility study.

Table 6-2. Planning Objectives

Objectives:
• Reduce flood hazards and flood damage costs in the project area to the maximum extent practicable.
• Reduce the adverse effects of flooding in the towns and cities of the Skagit River floodplain to the maximum extent practicable.
• Reduce the adverse effects of flooding on transportation delays to critical transportation corridors including, but not limited to, Interstate 5, State Routes 9, 20 and 536, and Burlington Northern-Santa Fe Railroad to the maximum extent practicable.
• Provide a systems wide approach to reducing flood damages in the populated areas of the basin to the maximum extent practicable.
• Protect existing public utility infrastructure from flood hazards to the maximum extent practicable.
• Reduce the threat of catastrophic levee failure and reduce flood damages to the agricultural community and rural residents to the maximum extent practicable.
• Restore existing degraded riverine habitats for salmonid and improve Skagit River ecosystem functions and processes.

Planning Constraints

Planning Constraints are statements about things we want to avoid, or things you cannot change, while striving to meet objectives. Table 6-3 presents planning constraints identified for this feasibility study.

Table 6-3. Planning Constraints

	Constraints:
•	A project must comply, to the extent possible, with the objective of Executive Order (EO) 11988, Floodplain Management. It is the intent of EO 11988 – and Corps policy – to: ➢ Reduce the hazards and risk associated with floods; ➢ Minimize the impact of floods on human safety, health and welfare; and ➢ Restore and preserve natural floodplain values. ➢ Avoid inducing floodplain development unless it is the only practicable alternative;
•	A project must comply with all other Federal, State, and local regulations, including environmental regulations.
•	Design the project with features compatible with existing agricultural and open space uses in rural areas to the maximum extent practicable.
•	Flood risk management measures must be formulated to be in compliance with Wild and Scenic River designation of significant portions of the Skagit River system upstream of Sedro-Woolley.
•	Recommended projects must support Corps Environmental Operating Principles.
•	Future climate change may raise sea levels in Puget Sound 2-4 feet within 50 years and needs to be considered in the design of the projects.
•	Avoid adverse impacts to the socio-economic and cultural aspects of the basin
•	Avoid adverse impacts to the aquatic and terrestrial environment to the maximum extent practicable. Minimize and compensate for unavoidable adverse impacts to the aquatic and terrestrial environment.

Planning Assumptions

Planning Assumptions are statements defining the parameters of the study scope, and provide guidelines, decision milestones, and boundaries for the study scope. Projects are formulated to meet the objectives, subject to constraints. Assumptions are modified as needed during the study process to reflect changing conditions. Table 6-4 presents planning some of the key assumptions for this feasibility study.

Table 6-4. Planning Assumptions

Assumptions:
• The life of proposed flood risk management and environmental projects is considered 50 years for the basis of economic, environmental, and benefit analysis. The base year for the 50 year period of analysis begins when project construction is completed and the project is put into service.
• Areas being evaluated for flood risk management consist of the town of Hamilton and the area downstream from Sedro-Woolley to the mouth of the Skagit River.
• The impact evaluation area for the study goes from the training area of the Upper Baker Dam and reservoir to the tidelands of the Skagit River and Padilla Bay.
• Hamilton is being considered for nonstructural flood risk management and relocation. A Section 205 study completed by the Corps in the 1980's indicated that a structural solution for Hamilton is not feasible.
• Measures that have been dropped from the feasibility study by previous screening for economic or environmental reasons are: dredging of the Skagit River main stem to Sedro-Woolley and modifications to the Seattle City Light dams (excepting operational changes at Ross Dam).
• The PMP will be reevaluated at key phases throughout the feasibility study as well as at the initiation of each fiscal year.
• Hydropower losses to Baker Dams or Ross Dam from additional flood risk management storage are considered a project cost.
• The Baker Dams alternative is being carried as a "locally preferred plan". If it is recommended for Federal implementation (based on environmental, socio-economic, cultural impacts, engineering feasibility and risks), costs greater than the alternative identified by the Corps as the National Economic Development Plan (least cost, most net benefits) will be paid 100% by the local sponsor. The local sponsor will pay all operation and maintenance costs for any recommended project, including hydropower losses, if pertinent.
• Climate change is not included in the HH model. There is currently no accepted protocol for dealing with potential climate change on basin hydrology. Some sensitivity studies can be included during Planning, Engineering, and Design if needed to provide "worst case" scenarios as a result of various climate outcomes. Potential increases in tidal flooding will be evaluated in project design to determine whether projects could fully function in a reasonable climate change situation.
• It is assumed that the Corps will not conduct detailed, expensive scientific and sediment studies of the impacts of a Padilla Bay bypass to eelgrass beds. The Corps will attempt to provide potential scenarios based on historic records
• Presumes no permanent floodwall/levee system in Mount Vernon, nor a setback of Diking District 12 levees. Constructed projects will be incorporated into the Corps without project condition analysis as appropriate. Only flood reduction projects having obtained appropriate permits and project funding will be included in the future without project condition.
• The GI study will evaluate ecosystem restoration projects compatible with selected FDR projects. Preference will be give to restoration that is associated with the recommended flood risk management plan. All restoration projects need to have a hydraulic nexus, and be incrementally justified. Primary consideration will be give to providing necessary mitigation for the recommended plan. Ecosystem restoration projects, to count as increased project benefits, will need to exceed the requirements for mitigation.

Measures Screening

Skagit County and the Corps have developed an array of structural and nonstructural measures for addressing problems and opportunities and for achieving project objectives. These measures include both flood risk management measures, and a preliminary list of ecosystem restoration measures. These measures have been presented to the public at several workshops in Skagit County, and to resource and tribal groups.

During the Reconnaissance Phase several measures were removed from further consideration during the feasibility phase (Table 6-5). Measures carried into feasibility are shown in Table 6-6. Appendix A provides a descriptive overview of each of the measures from Table 6-6. Urban Reaches were identified to aid in discussion of the measures (**Plates 12-16**). Further screening of measures will be conducted in the future as part of the plan formulation process.

Table 6-5. – Eliminated Flood Risk Management Measures from Initial Screening

Measures screened out	Rationale
• Dredging of Skagit River from bay to Sedro Woolley	Not hydraulically viable, nor environmentally acceptable. High maintenance costs. This measure was found to have high O&M costs, high initial costs, and significant environmental issues. Rather than prescribe a measure such as this, site specific dredging could be considered as part of an overall alternative.
• New dams with flood control storage	Not institutionally viable due to "Wild and Scenic River" status of Sauk River and Skagit River upstream of Sedro-Woolley.
• Modifications to Seattle City Light's Gorge and Diablo Dams	Gorge and Diablo too small to provide significant storage.

The remaining measures (Table 6-6) are a complete list of feasible measures that project planners will use as a foundation for grouping measures into alternatives. Measures will be grouped based on best hydrologic performance and compatibility to achieve the purpose and objectives of the project. Once the measures are grouped, they will be compiled as a Range of Alternatives suitable for evaluation against the objectives of the project. It is possible that certain measures are determined by the Corps to be excluded from further consideration but because of sponsor support may be carried for further consideration under the Locally Preferred Plan (LPP). These measures will be expressly identified as locally preferred.

Table 6-6 – Remaining Measures to be Evaluated– by Type

Modifications of Existing Dams operational and structural changes		Description
1	Addt'l storage at Upper Baker Dam	Evaluating 85K, 100K storage, 110K storage, altered timing of rule curve release during at Upper Baker Dam during flood.
2	Addt'l storage at Lower Baker Dam	
3	Addt'l storage at Ross Dam	
Levees – Modifications, setbacks and flood walls		**Description**
4	Nookachamps Storage	Evaluate Levee structure on left bank from Hwy 9 to the BNSF bridge.
5	Hart's Slough Storage	Evaluate levee structure on the left bank from Hwy 9 bridge to start of levee system.
6	Sterling Levee	Evaluating alignments to eliminate flooding upstream of Burlington.
7	Setback levees downstream of 3-br. Corridor	Setback levees on main-stem Skagit River and North and South Forks. May entail modification of Division Street bridge and North Fork and South Fork bridges. Restoration potential.
8	Three bridge corridor – Setback levees	Setback levees in transportation corridor, with and without bridge modification. Restoration potential.
10	Setback Main stem and North fork only	Setback levees on main stem Skagit and North Fork. Restoration potential.
13	Setback Levees w/o excavation	Setback levees from 3 bridge corridor, for left bank, right bank, and left and right banks of N. and S. Forks. Restoration potential.
14	Improve levee system – Left bank	Left bank levee improvements only. Restoration potential.
15	Improve levee system – Right bank	Right bank levee improvements only. Restoration potential.
16	Mount Vernon Floodwall	To protect Mount Vernon business district, either as a stand-alone measure or in combination with setback levees.
Bypass Systems		**Description**
17	North Swinomish Diversion (Avon bypass)	Bypass from left bank of Skagit River to Padilla Bay or Swinomish Slough. Restoration potential.
18	Fir Island Bypass	Bypass from north Fork Skagit River through to Skagit Bay. Restoration potential.

19	Samish Bypass	Bypass from upstream of Sedro-Woolley to Samish Bay. Restoration potential.
20	Mount Vernon Bypass	Right bank bypass through river bend downstream of Mount Vernon. An alternative to a floodwall and setback levee in this river reach. Restoration potential.
Relocation/Ecosystem Restoration		**Description**
22	Cockreham Island	Removal of levee, restoration of riparian habitat
23	Estuarine restoration projects (misc)	Removal of agricultural dikes/tide gates, restoration of sloughs, marine shoreline
24	Riparian restoration projects (misc)	Removal of levees, restoration of riparian vegetation, off-channel habitat.
Non-structural		**Description**
25	Non-structural measures	May include flood proofing, relocation, purchase of floodway easements, flood warning and the establishment of evacuation routes. May be combined with other measures. Restoration potential.
26	City of Hamilton	Relocation/floodproofing of town. Restoration potential.
27	Debris Management	Routine debris management and removal from bridges and river constrictions.
Ring Dikes		**Description**
28	Sedro Woolley	Levee system to protect Sedro-Woolley
29	Sedro Woolley STP	Ring dike to protect treatment plant.
30	Sedro Woolley Hospital	Ring dike to protect hospital
31	Burlington	Ring dike to protect city of Burlington
32	North Mount. Vernon	Ring dike to protect north Mount Vernon
33	West Mount Vernon	Ring dike to protect West Mount Vernon
34	East Mount Vernon	Ring dike to protect East Mount Vernon
35	La Conner	Ring dike to protect La Conner
36	Clear Lake	Ring dike to protect Clear Lake
37	Anacortes Water Treatment Plant	Ring dike to protect Water treatment facility
Bridges		Description
38	Bridge Modifications	Widening of bridges I-5, BNRR, and Burlington Blvd Bridge. Restoration potential.

Measures remaining under consideration after the preliminary screening process will be refined to maximize hydraulic performance and reflect the results of an updated levee failure analysis.

These measures will be modeled using the latest HEC-FDA model to determine benefit cost ratios. This modeling will provide the economic data that will be carried through the remaining three years of alternatives analysis and the Environmental Impact Statement.

A screening will be applied to the measures remaining under consideration that will employ criteria including the following (not in order of priority):

1. Quantified Hydraulic Performance.
2. Benefit Cost Ratio (including operation and maintenance, mitigation, construction, and real estate).
3. Tribal Support.
4. Environmental Issues and Resource Support.
5. Local Support.
6. Stakeholder Support
7. Residual flooding risk/safety

Alternatives Formulation

The measures remaining under consideration after the preliminary and secondary screening processes will serve as the building blocks of the project alternatives. Each of the remaining measures will be refined hydraulically to provide optimal performance for each alternative.

Measures will be grouped based on hydrologic and hydraulic performance for the initial Range of Alternatives. Through an iterative process, the Project Development Team will work to improve hydraulic performance, reduce environmental impacts through improved footprints and measure locations, and increase economic benefits to improve the benefit/cost ratio.

This Range of Alternatives will be presented to the general public and stakeholders as the NEPA scoping period is opened to solicit comments from the public on the project constraints and opportunities, without project conditions reporting, measures reporting and screening, and the Range of Alternatives.

Once comments have been recorded, the Alternatives will undergo a similar screening process to the Secondary Measures Screening. This sieve will provide quantitative analysis of the alternatives under consideration to determine viability and likelihood of each alternative outperforming those within the range. The lower performing alternatives will be refined in an attempt to improve performance. If that performance still is not sufficient to make the alternative competitive to those under consideration, the alternative will be excluded from further consideration. Features or elements, formerly measures, of these excluded alternatives may be salvaged for inclusion into the selected plan.

References

SCCFHMP. Skagit County. 2003. Skagit County Comprehensive Flood Hazard Management Plan: Draft Interim Update to 1989 Skagit County Comprehensive Flood Control Management Plan.

Next Steps

Feasibility Scoping Meeting Compliance

Following the Feasibility Scoping Meeting, the Project Delivery Team will work to address all Vertical Team comments and directives received at the meeting. Technical Appendices and Feasibility Report documentation will be revised as appropriate.

Technical Updates and Revisions

As noted in Sections 4 and 5, revisions to geotechnical levee stability analysis, hydraulic modeling, and economic analysis will be revised to reflect current conditions. Technical Appendices and Feasibility Report documentation will be revised as appropriate.

Integration of Ecosystem Restoration Measures

Ecosystem restoration measures will be identified and incorporated into the plan formulation process. The measures will be fully documented in the revised Feasibility Report and Technical Appendices as appropriate.

Engineering Design

All measures under consideration will be developed to approximate 10% concept design level. Cost estimates will be developed for measures to facilitate further comparison and screening of measures during plan formulation.

Plan Formulation

Flood risk management and ecosystem restoration measures will be combined into various alternative plans for addressing project objectives. Damages reduced and residual damages will be quantified through economic modeling for each measure. Ecosystem Restoration benefits of measures will be quantified and relative cost effectiveness of ecosystem restoration measures will be evaluated. A National Economic Development (NED) Plan including any mitigation requirements will be identified that maximizes net benefits to the Nation and it consistent with Corps Environmental Operating Procedures. If desired by Skagit County, a Locally Preferred Plan may be identified that differs from the NED Plan.

Feasibility Report/Decision Document

A draft feasibility report will be prepared. This FSM read-ahead report will be modified to become the feasibility report. Sections 4 and 5 of this report will be updated to reflect studies and findings that occur after the FSM. Section 6 will be updated extensively to document the plan formulation and plan evaluation processes to occur following the FSM. New sections of the report will be added to document the selected plan; requirements for plan implementation; technical and legal review; summary of coordination, public views and comments; and the study recommendations as described in the following sections.

Description of Selected Plan

The feasibility report will identify a recommended plan for implementation. The report will provide a detailed description of the plan including: cost, benefits/accomplishments, attainment of objectives, description of structural and non-structural features, any operational changes to existing water resource projects, environmental impacts, mitigation features and expected effects, status of all NEPA and ESA compliance requirements; real estate requirements and acquisition schedule, and operation and maintenance requirements.

Plan Implementation

The feasibility report will summarize the cost sharing requirements and procedures necessary to implement features of the recommended plan. This section of the report will address:division of Federal and non-Federal responsibilities for implementing the Recommended Plan; overview of the Preconstruction Engineering and Design Phase for the project; discussion of the requirement for and provisions to be included in the Project Cooperation Agreement for Construction; Project Construction Sequencing, Project Operation and Maintenance Responsibilities; Project Cost Allocation (allocating project costs to specific project purposes they serve) and Cost Apportionment (dividing responsibility for payment of project costs between Federal government and appropriate non-Federal interests); specification of Institutional Requirements including evaluation of non-Federal sponsor's financial ability to finance their share of project costs; Environmental Requirements; Status of Compliance with Environmental Laws, Regulations, and Treaties; and Sponsorship Agreements.

Statement of Legal and Technical Review

The feasibility report will include documentation of Quality Control Procedures, Agency Technical Review, and Independent External Peer Review processes as appropriate. A certification of Technical and Legal Review will be included with the Feasibility Report consistent with Corps Regulations.

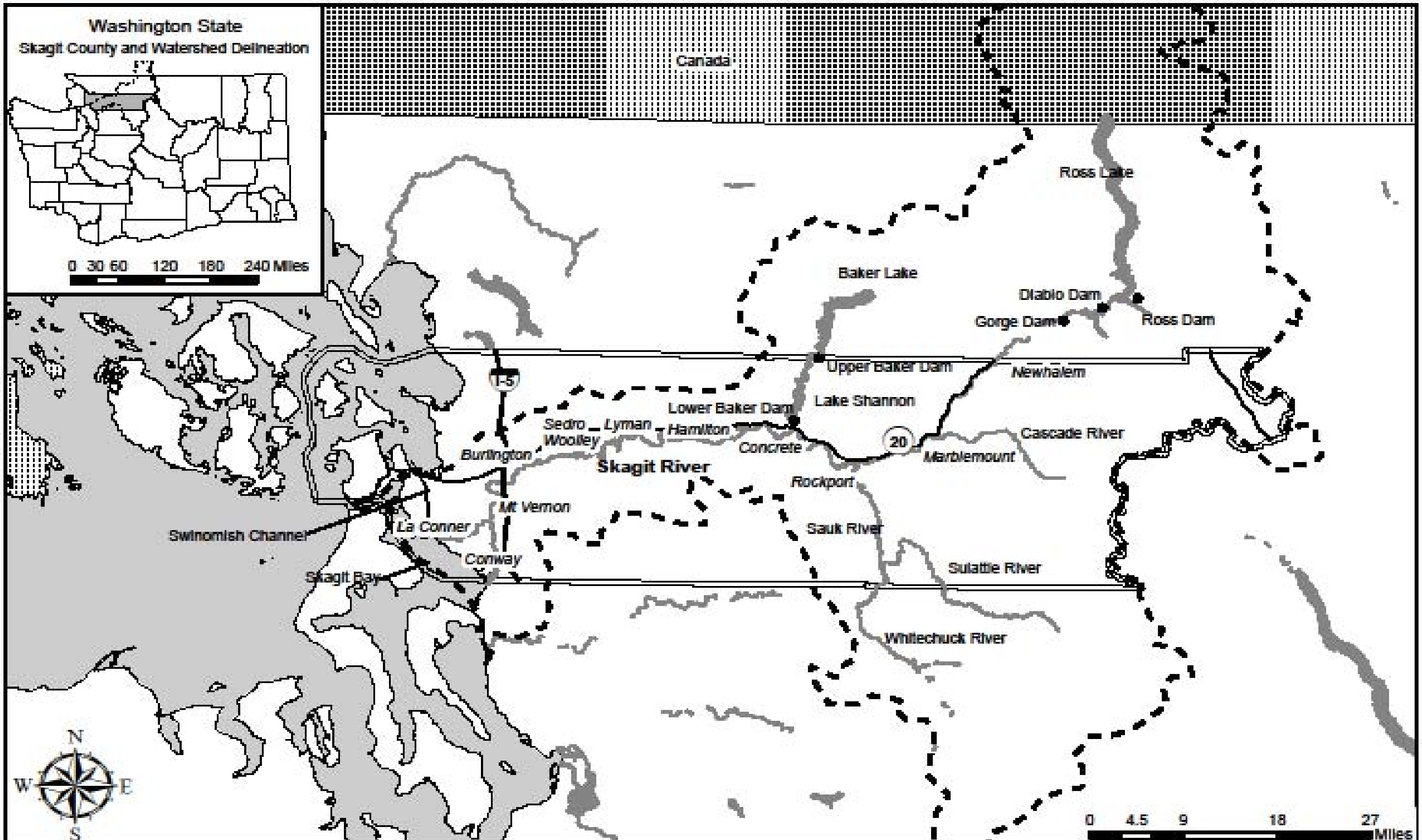
Summary of Coordination, Public Views, and Comments

The feasibility report will include documentation of agency and Tribal coordination activities as well as all public involvement activities conducted as part of the feasibility study and NEPA process. The report will document all formal comments received through the Public Comment and Agency Coordination processes.

Study Recommendations

The feasibility report will include a recommendation by the Seattle District Commander. The recommendation will be determined based upon careful review of findings of final engineering studies; plan formulation and evaluation activities; environmental impacts analysis; and views of other agencies Tribes, and the public. The recommendation will indicate if it has been determined that there is a Federal interest in implementing a flood risk management and ecosystem restoration alternative in the study area.

Plates



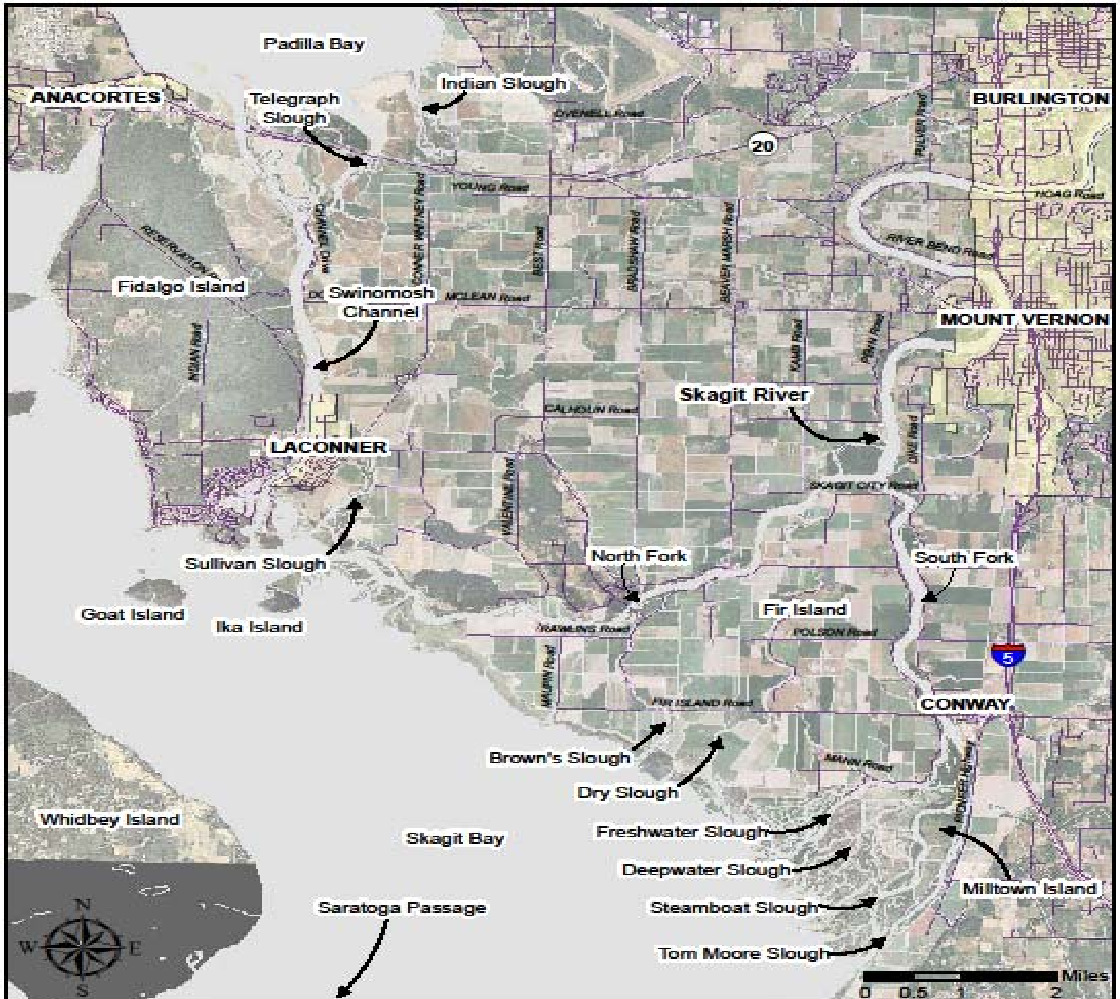
USACE Seattle District

Plate 1. Study Area, Location, and Vicinity

Skagit River Flood Risk Management and
Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

Water Features
Skagit County
Skagit River Basin
Water Projects



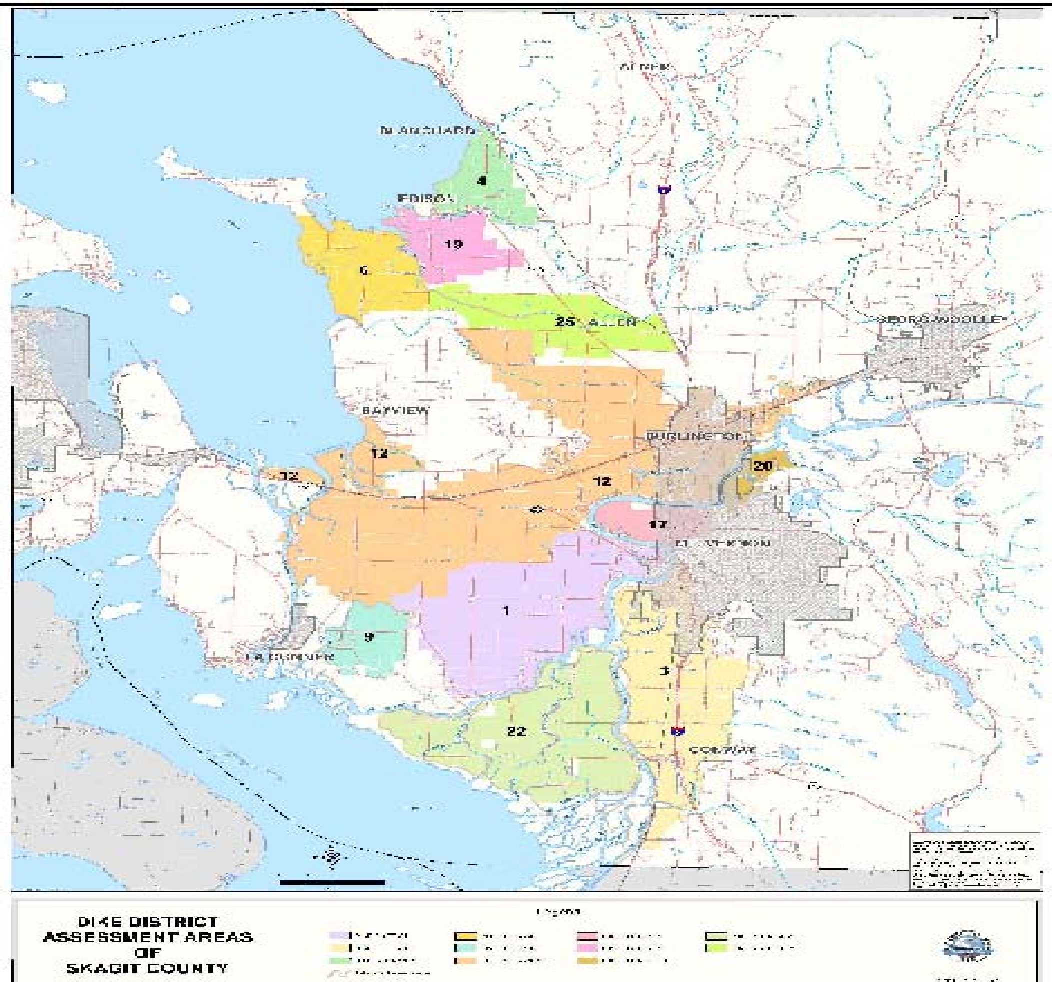
USACE Seattle District

Plate 2. Lower Basin Detail

Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

Features and Places
Roads
Cities



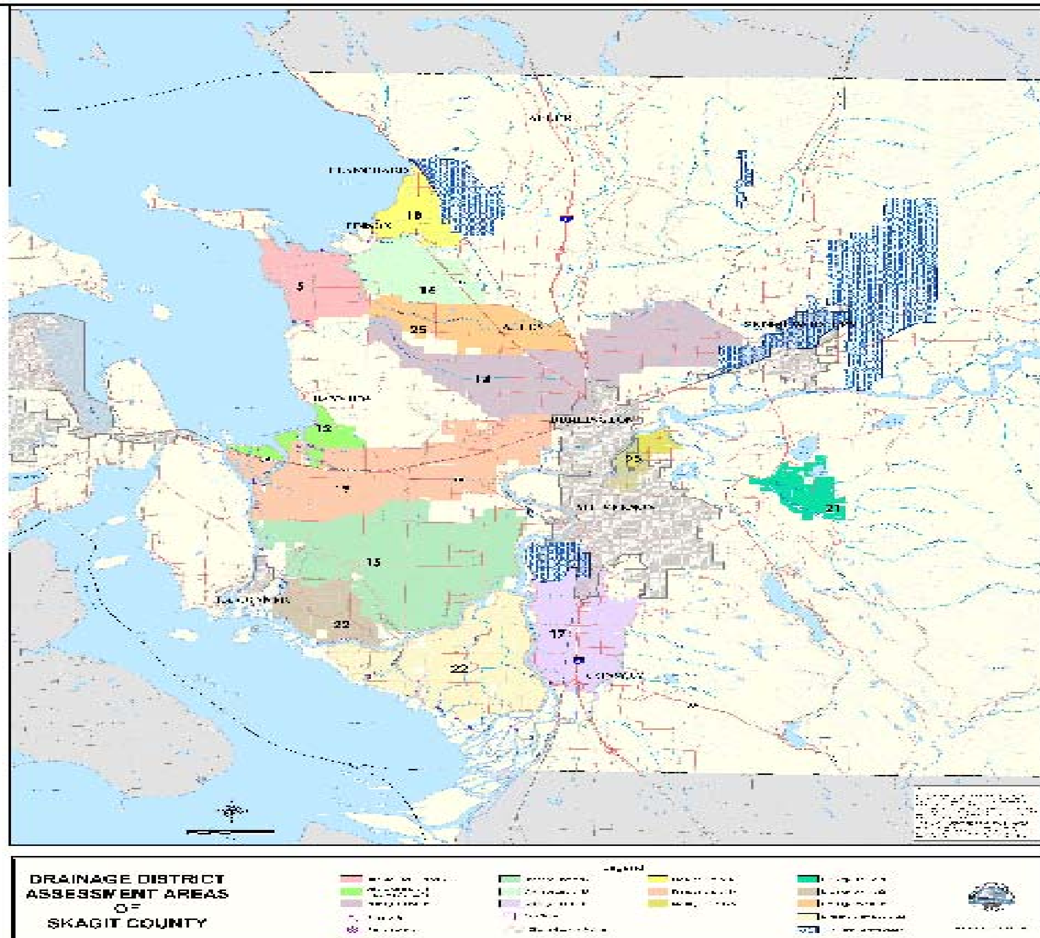
USACE Seattle District

PLATE 3. Diking Districts

Skagit River Flood Risk Management and
Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

Source:
Skagit County GIS.
Downloaded via website.
No b&w version available.
May not reproduce well in b&w.



USACE Seattle District

PLATE 4. Drainage Districts

Skagit River Flood Risk Management and
Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

Source:
Skagit County GIS.
Downloaded via website.
No b&w version available.
May not reproduce well in b&w.

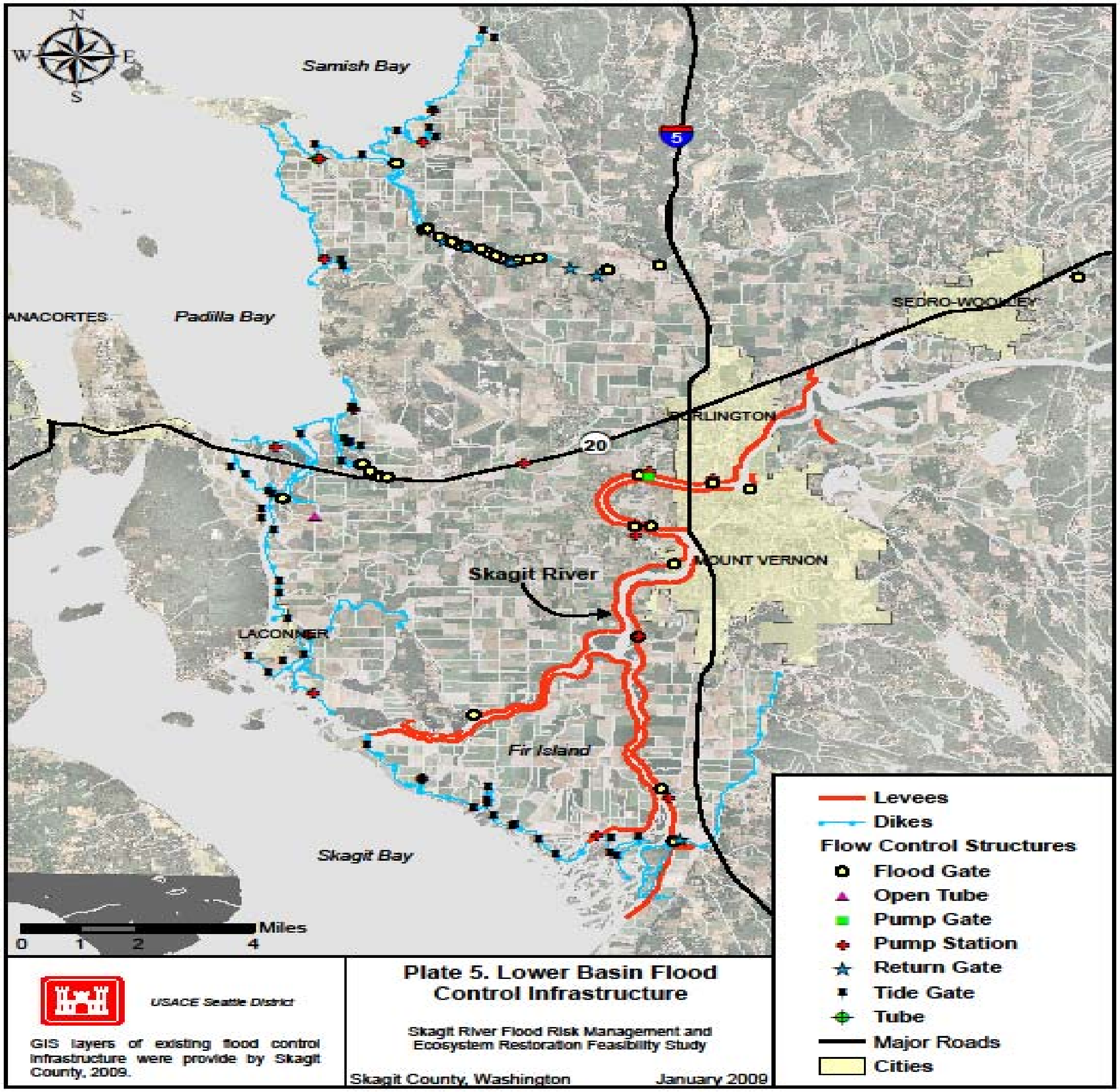
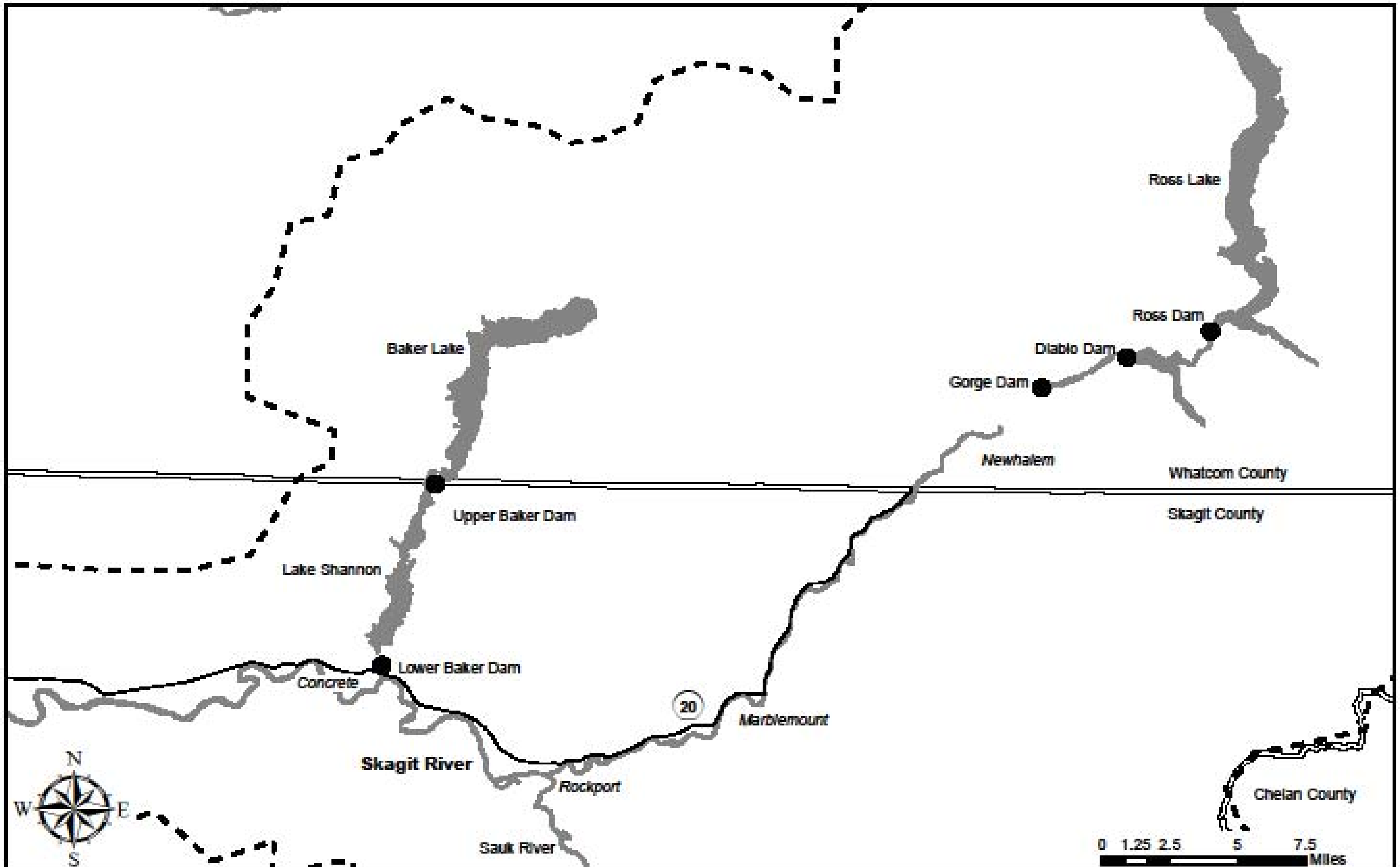


Plate 5. Lower Basin Flood Control Infrastructure



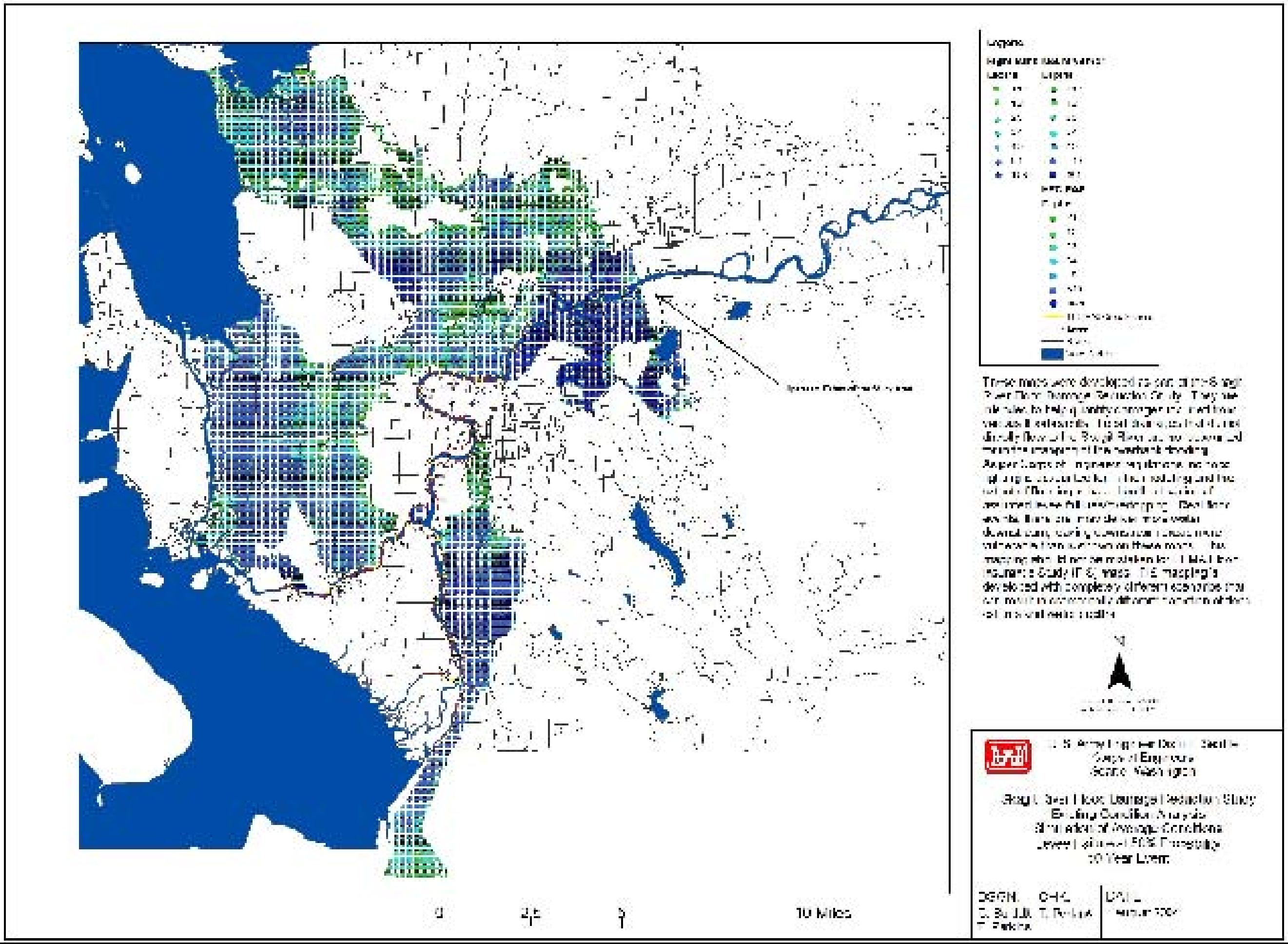
USACE Seattle District

Plate 6. Dams in the Study Area

Skagit River Flood Risk Management and
Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

Water Features
County Line
Skagit River Basin
Water Projects



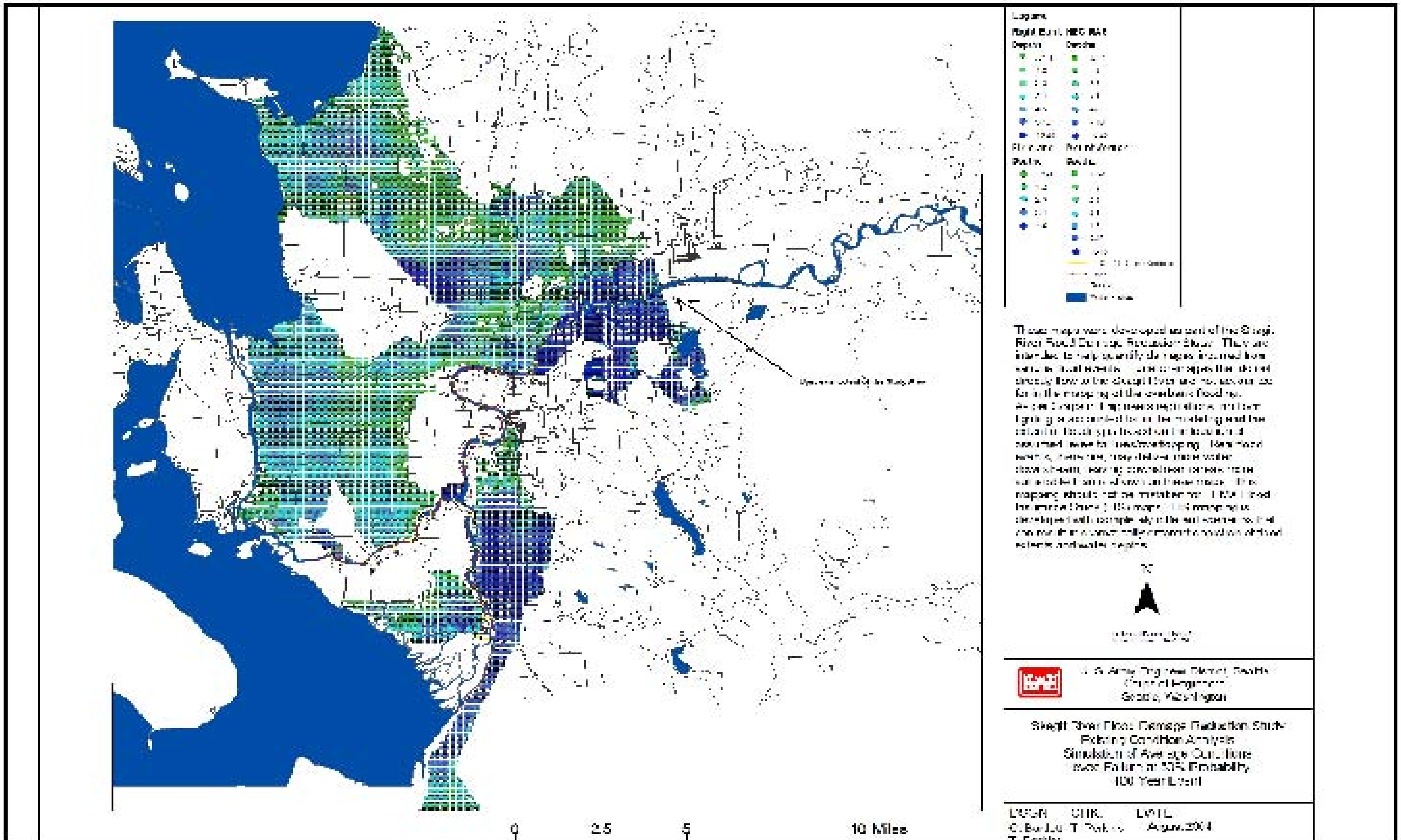
USACE Seattle District

Plate 7. 50 year Floodplain (2004)

Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is a reproduction of the figure included in the Seattle District's Hydraulics report and is included here for quick reference. The Hydraulics appendix also contains the 5, 10, 25, 75, and 250 year floodplain maps.



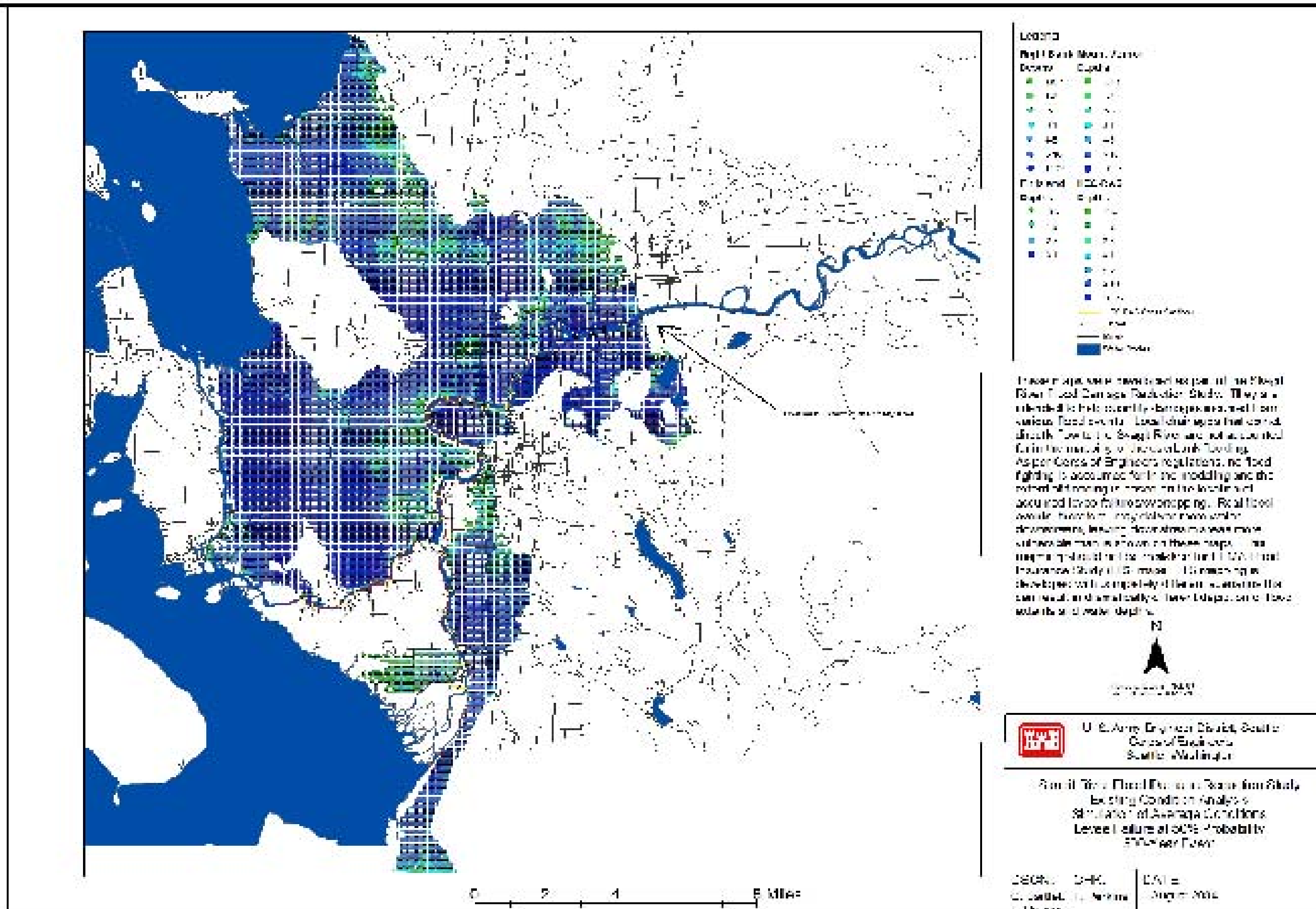
USACE Seattle District

Plate 8. 100 year Floodplain (2004)

Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is a reproduction of the figure included in the Seattle District's Hydraulics report and is included here for quick reference. The Hydraulics appendix also contains the 5, 10, 25, 75, and 250 year floodplain maps.



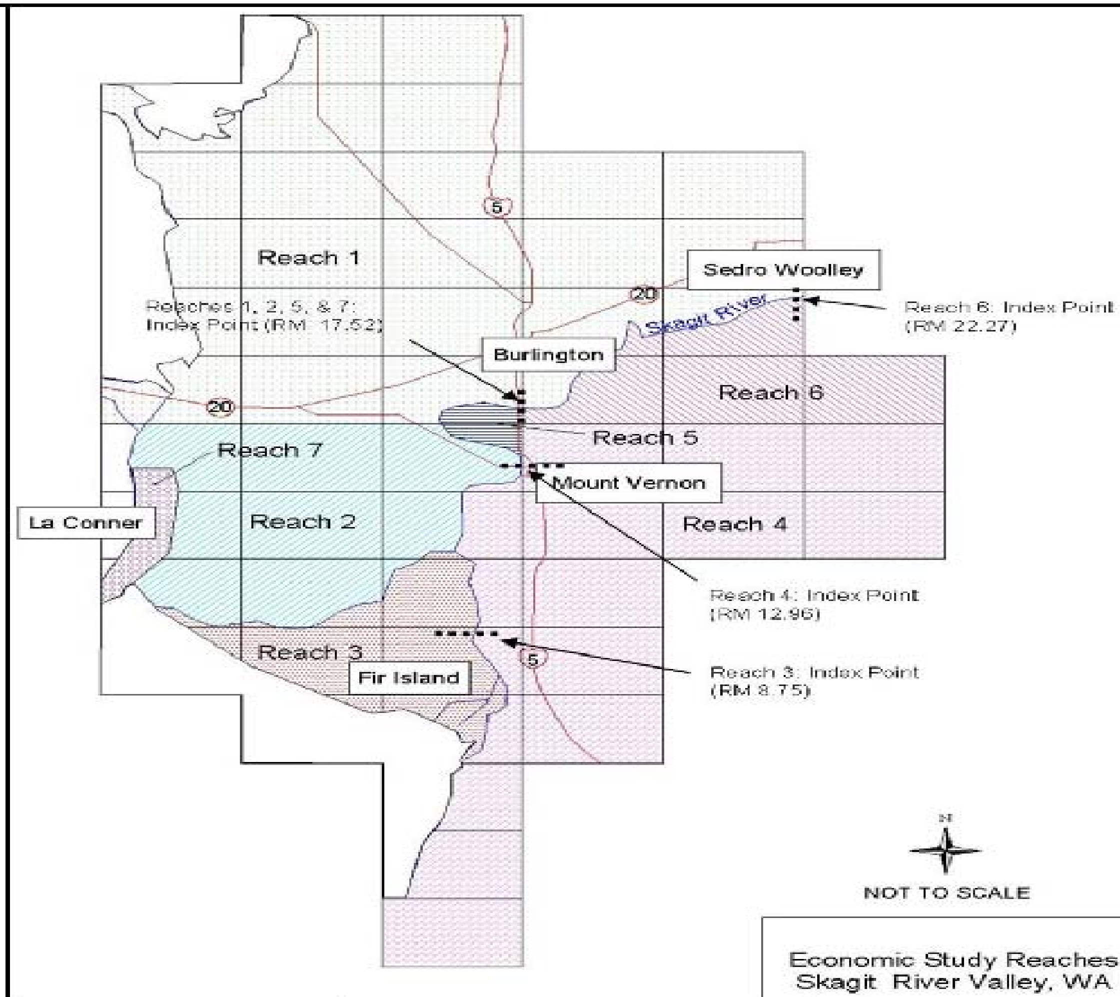
USACE Seattle District

Plate 9. 500 year Floodplain (2004)

Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is a reproduction of the figure included in the Seattle District's Hydraulics report and is included here for quick reference. The Hydraulics appendix also contains the 5, 10, 25, 75, and 250 year floodplain maps.



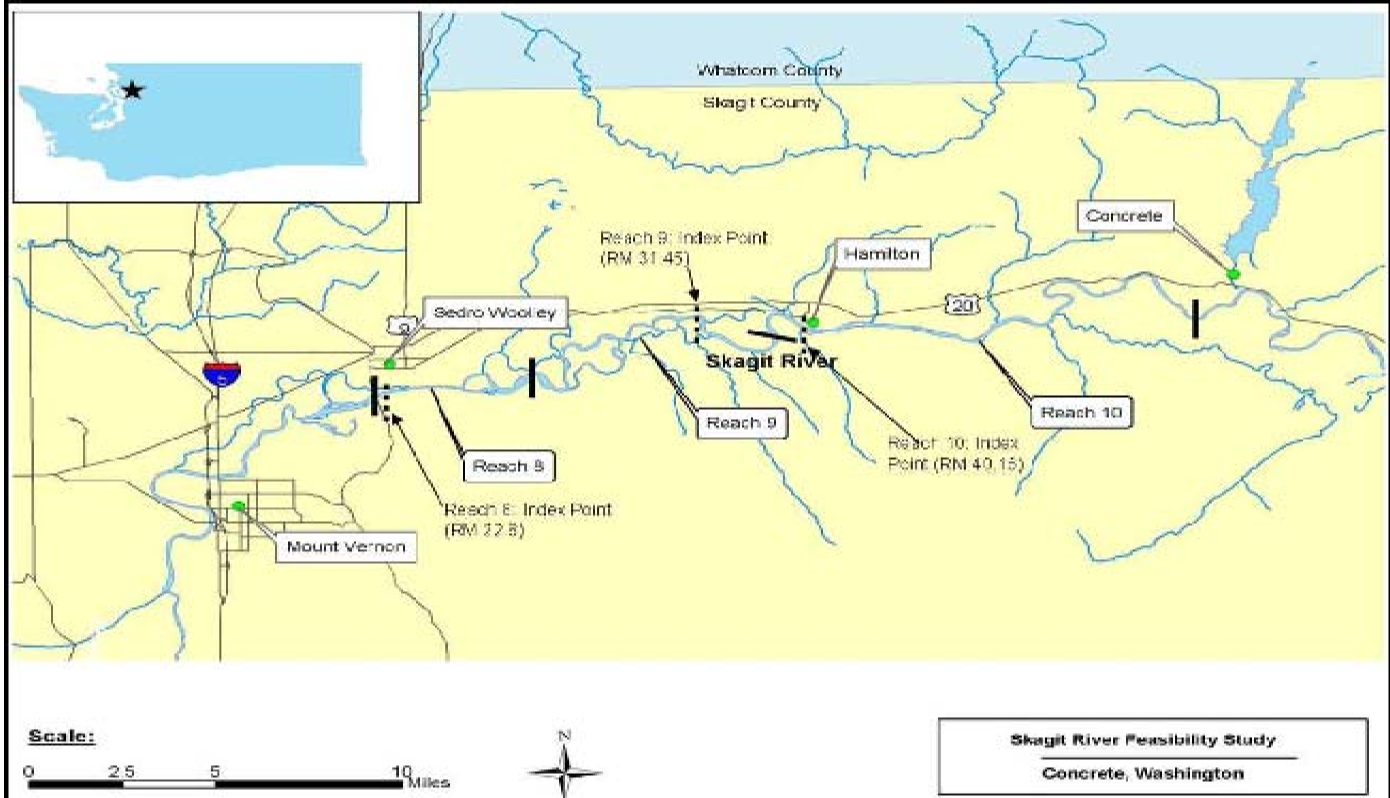
USACE Seattle District

Plate 10. Downstream Study Reaches

Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is based on an image file and cannot be edited.



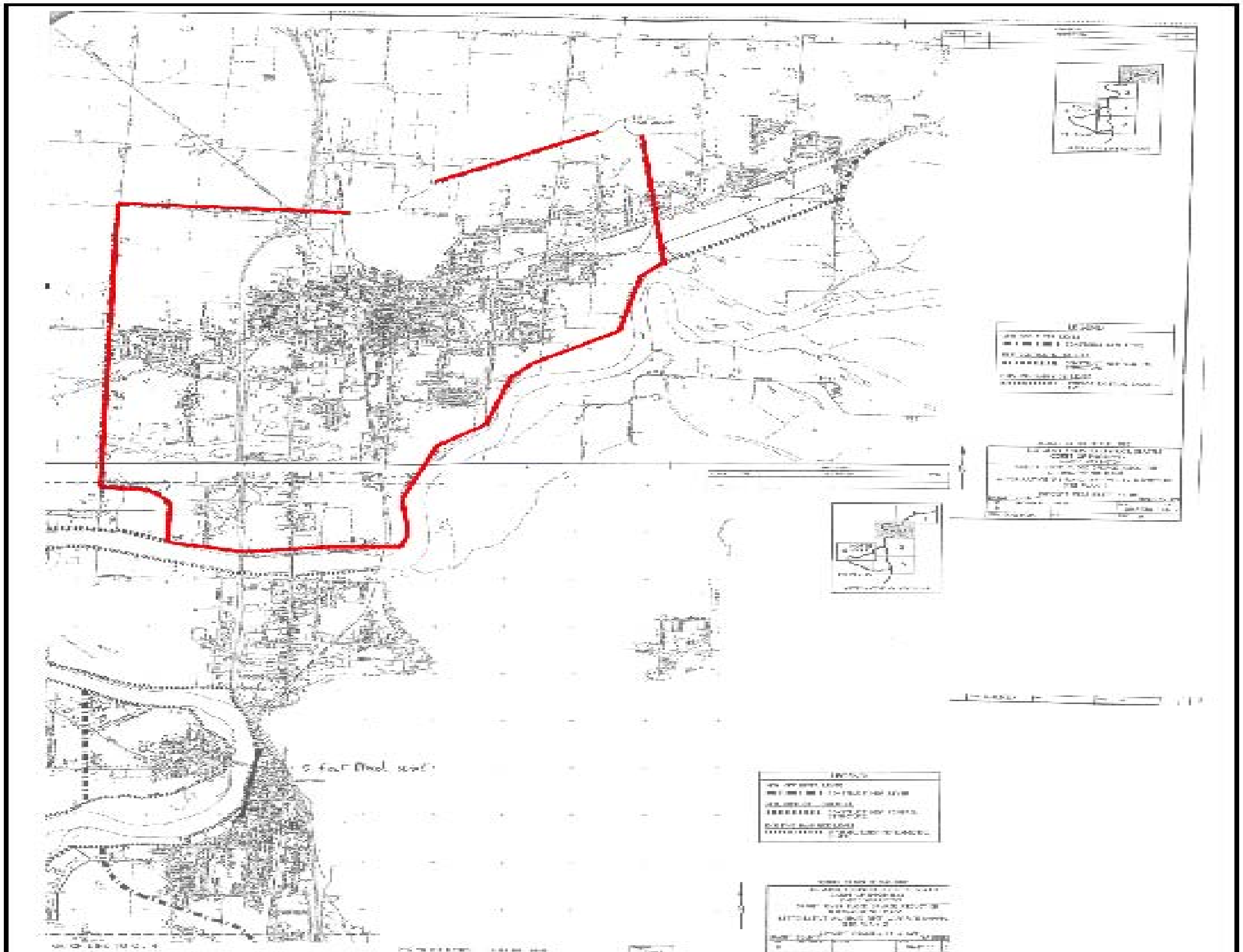
USACE Seattle District

Plate 11. Upstream Study Reaches

Skagit River Flood Risk Management and
Ecosytem Restoration Feasibility Study

Skagit County, Washington January, 2009

This plate is based on an image file and cannot be edited.



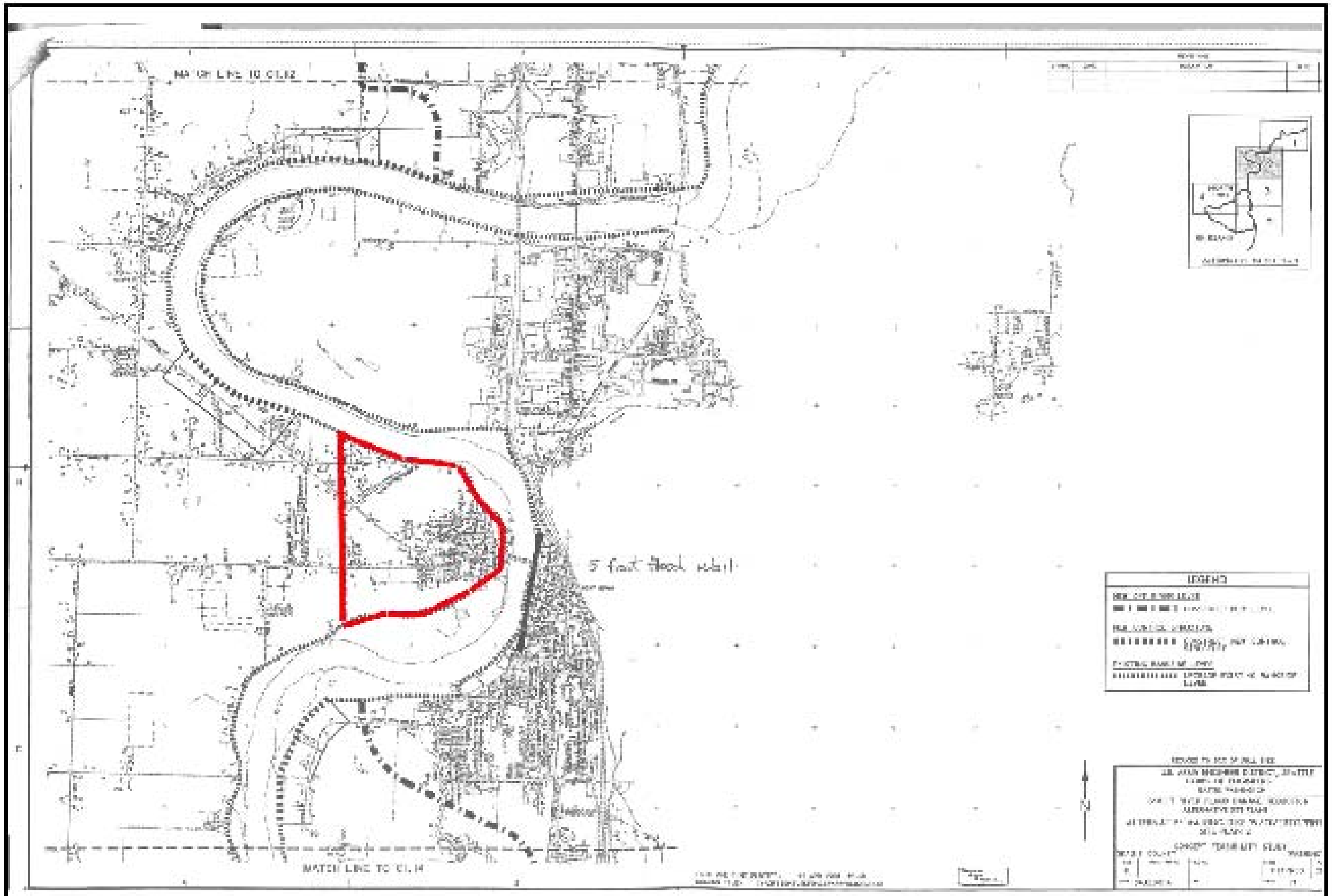
USACE Seattle District

PLATE 12. Urban Reach 1A in Red

Skagit River Flood Risk Management and
Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is based on an image file and cannot be edited.



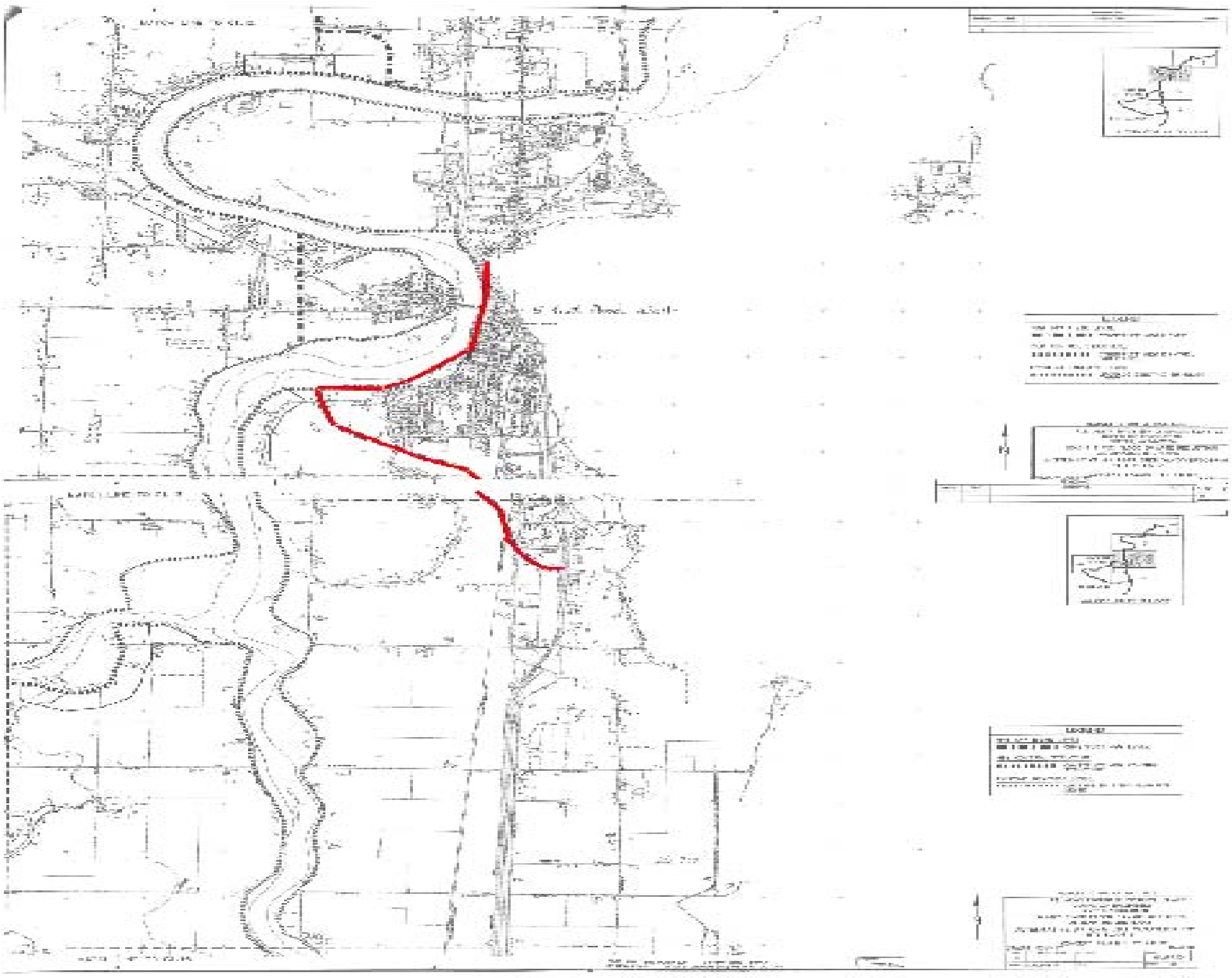
USACE Seattle District

PLATE 13. Urban Reach 2A in Red

Skagit River Flood Risk Management and
Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is based on an image file and cannot be edited.



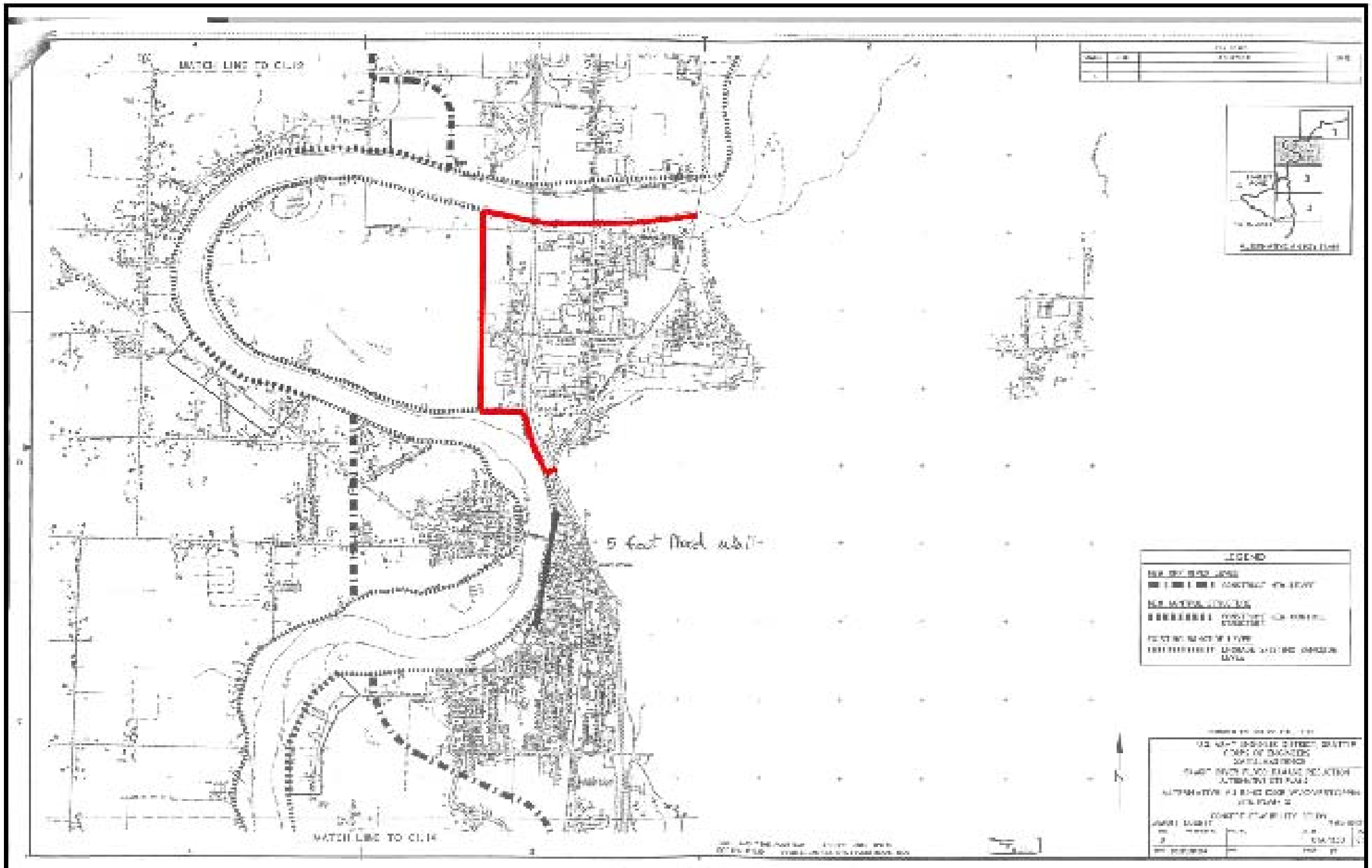
USACE Seattle District

PLATE 14. Urban Reach 4A in Red

Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is based on an image file and cannot be edited.



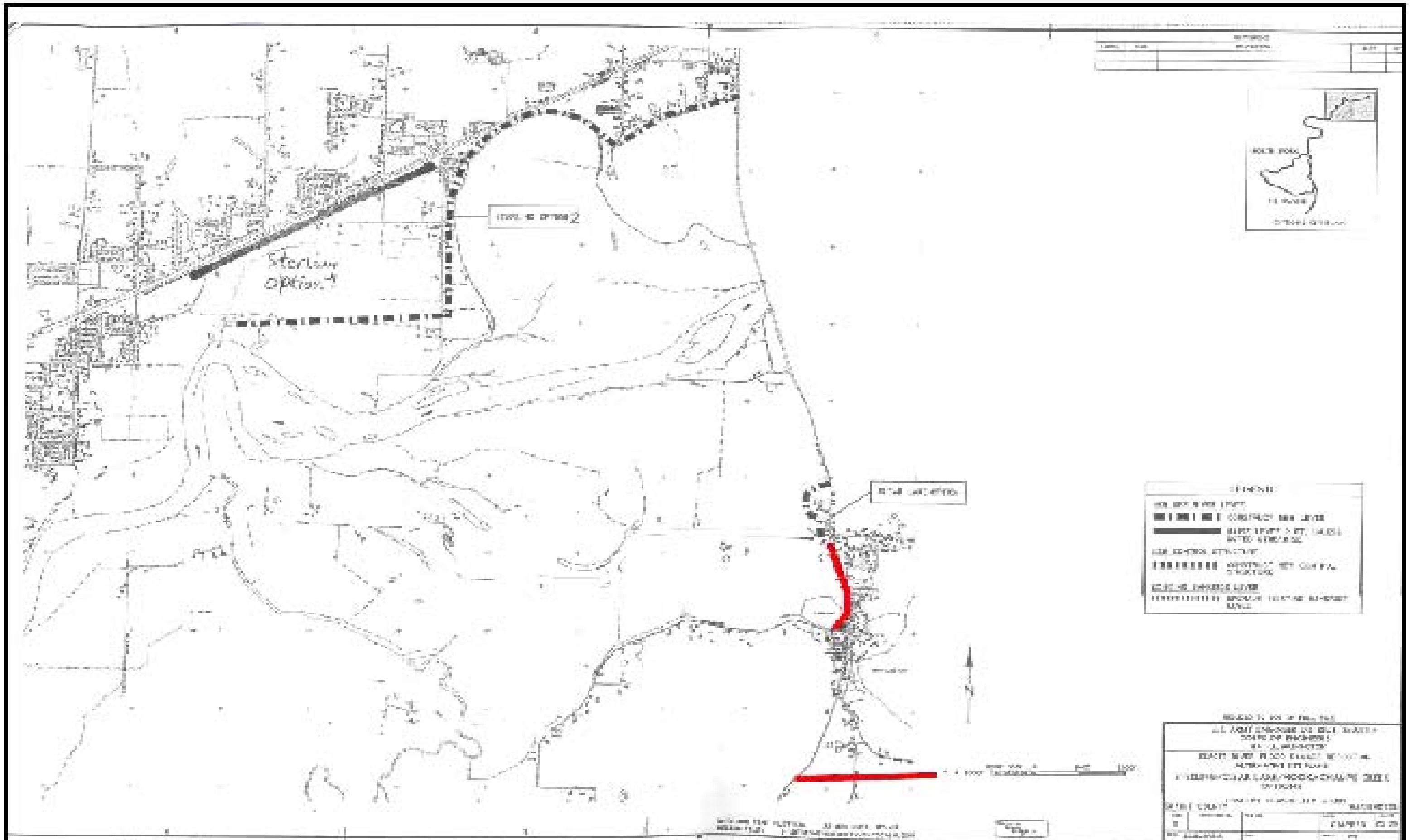
USACE Seattle District

PLATE 15. Urban Reach 5A in Red

Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is based on an image file and cannot be edited.



USACE Seattle District

PLATE 16. Urban Reach 6A in Red

Skagit River Flood Risk Management and Ecosystem Restoration Feasibility Study

Skagit County, Washington January 2009

This plate is based on an image file and cannot be edited.

Appendix A

Description of Identified Measures

Table of Contents

MEASURE 10 – SETBACK LEVEES MAINSTEM AND NORTH FORK ONLY 20

Modification of Existing Dams

Measure 1 – Upper Baker Dam

Upper Baker Dam is located at River Mile (RM) 9.3 on the Baker River tributary to the Skagit River, which comes into the Skagit River (RM 56.5) just upstream of the Concrete Gage. The drainage area above Upper Baker Dam is 215 square miles which is roughly 7% of the drainage area for the Skagit River near Mount Vernon and typically contributes roughly 12% of the peak flow seen on the Skagit River. The Corps of Engineers currently has the authorization for flood control space that maximizes at 74,000 acre-feet on November 15th of the flood season. With the existing flood control space, Upper Baker Dam outflow's current contribution to the 100-year flow is 9,000 cfs which represents 4% of the total flow. These measures are designed to reduce the flow contribution coming from Upper Baker Dam with additional storage, timing, and minimum outflow adjustments.

The major potential advantage of Measure 1 is the reduction in flood flows during more frequent, smaller flood events. Potential disadvantages include increased flood flows during large events, impacts to endangered species, and hydropower losses. In addition, design must meet new Corps HQ structure and design requirements. Resolution of designation of FERC Probable Maximum Flood would be required for the HQ to approve this measure. Finally, the measure only reduces flows from 15% of total inflow to mainstem.

Measure 1A – Upper Baker Dam – 74K Storage – 0 cfs Outflow

This measure reduces the minimum flow released from Upper Baker Dam from 5,000 cfs to 0 cfs. The flood storage remains the same at 74,000 acre-feet and the flood control follows what is set in the Water Control Manual. This measure reduces the outflow at the dam for flood events up through a 25-year event but fills up the storage quicker and causes more flow to be released at larger flood events such as the 100-year. The benefits are seen because of the higher frequency of the lower events. Considerations for further Study:

- A more detailed analysis of possible structural modifications at the dam (necessary to meet Corps safety requirements) will be developed based on HQ guidance.
- This measure reduces flood flows for more frequent events (less than a 50-year event) but causes the storage to fill up prematurely in larger flood events, which causes increases in flows. Areas that normally do not see flooding until the larger flood events such as Sedro-Woolley have negative benefits because of this while most of the other areas see a benefit.
- These estimates of benefits and costs should be considered preliminary and are provided for the purpose of initial screening of management measures.
- Corps Headquarters will need to determine whether the dam meets current Corps operation and design requirements. If the dam does not meet criteria, Headquarters will need to identify what dam modifications are required and these costs will be attributed to the measure. This effort cannot be initiated until FERC determines what modifications may be required to the dam for Puget Sound Energy (PSE) to meet FERC requirements.
- This measure has the potential to increase flooding for Sedro-Wooley in major events. This would need to be mitigated.
- Costs to structurally modify the dam have not been determined or included in this evaluation. Dam maintenance and operation costs attributed to additional flood storage would be a 100% local cost.
- Costs of measure are based strictly on hydropower loss from change in operations of the dam. Power loss compensation would be a 100% local cost.
- Potential environmental impacts have not been evaluated. Need to assure that this measure would not impact critical in-stream flows (i.e. spawning beds and fish stranding).

Measure 1B – Upper Baker Dam – 85K Storage – 0 cfs Outflow

This measure reduces the minimum flow released from Upper Baker Dam from 5,000 cfs to 0 cfs and increases the flood storage from 74,000 acre-feet to 85,000 acre-feet. The flood control follows what is

set in the Water Control Manual. This measure reduces the outflow at the dam for all flood events up to a 75-year event and then is similar to existing conditions.
Considerations for further Study:

- This measure reduces flood flows for more frequent events (less than a 100-year event) but causes the storage to fill up prematurely in larger flood events, which causes increases in flows. Areas that normally do not see flooding until the larger flood events such as Sedro-Woolley have negative benefits because of this while most of the other areas see a benefit.
- These estimates of benefits and costs should be considered preliminary and are provided for the purpose of initial screening of management measures.
- Need determination of whether dam meets Probable Maximum Flood criteria and, if not, what would be necessary to meet the criteria.
- Corps Headquarters will need to determine whether the dam meets current Corps operation and design requirements. If the dam does not meet criteria, Headquarters will need to identify what dam modifications are required and these costs will be attributed to the measure. This effort cannot be initiated until FERC determines what modifications may be required to the dam for Puget Sound Energy (PSE) to meet FERC requirements.
- Measure has the potential to increase flooding for Sedro-Wooley in major events. This would need to be mitigated.
- Costs to structurally modify the dam have not been determined or included in this evaluation. Dam maintenance and operation costs attributed to additional flood storage would be a 100% local cost.
- Costs of measure are based strictly on hydropower loss from change in operations of the dam. Power loss compensation would be a 100% local cost.
- Potential environmental impacts have not been evaluated. Need to assure that this measure would not impact critical in-stream flows (i.e. spawning beds and fish stranding).

Measure 1C – Upper Baker Dam – 100K Storage – 0 cfs Outflow

This measure reduces the minimum flow released from Upper Baker Dam from 5,000 cfs to 0 cfs and increases the flood storage from 74,000 acre-feet to 100,000 acre-feet. The flood control follows what is set in the Water Control Manual. This measure reduces the outflow at the dam for all flood events.

Considerations for further Study:

- This measure reduces flows for all events greater than a 2-year flood at all locations.

- These estimates of benefits and costs should be considered preliminary and are provided for the purpose of initial screening of management measures.
- Corps Headquarters will need to determine whether the dam meets current Corps operation and design requirements. If the dam does not meet criteria, Headquarters will need to identify what dam modifications are required and these costs will be attributed to the measure. This effort cannot be initiated until FERC determines what modifications may be required to the dam for Puget Sound Energy (PSE) to meet FERC requirements.
- Costs to structurally modify the dam have not been determined or included in this evaluation. Dam maintenance and operation costs attributed to additional flood storage would be a 100% local cost.

- Costs of measure are based strictly on hydropower loss from change in operations of the dam. Power loss compensation would be a 100% local cost.
- Potential environmental impacts have not been evaluated. Need to assure that this measure would not impact critical in-stream flows (i.e. spawning beds and fish stranding).

Measure 1D – Upper Baker Dam – 110K Storage – 0 cfs Outflow

This measure reduces the minimum flow released from Upper Baker Dam from 5,000 cfs to 0 cfs and increases the flood storage from 74,000 acre-feet to 110,000 acre-feet. The flood control follows what is set in the Water Control manual. This measure reduces the outflow at the dam for all flood events but is only marginally better than 100K storage even in large events.

Considerations for further Study:

- This measure reduces flows for all events greater than a 2-year event at all locations.
- These estimates of benefits and costs should be considered preliminary and are provided for the purpose of initial screening of management measures.
- Corps Headquarters will need to determine whether the dam meets current Corps operation and design requirements. If the dam does not meet criteria, Headquarters will need to identify what dam modifications are required and these costs will be attributed to the measure. This effort cannot be initiated until FERC determines what modifications may be required to the dam for Puget Sound Energy (PSE) to meet FERC requirements.
- Costs to structurally modify the dam have not been determined or included in this evaluation.
- Dam maintenance and operation costs attributed to additional flood storage would be a 100% local cost.

- Costs of measure are based strictly on hydropower loss from change in operations of the dam. Power loss compensation would be a 100% local cost.
- Potential environmental impacts have not been evaluated. Need to assure that this measure would not impact critical in-stream flows (i.e. spawning beds and fish stranding).

Measure 2 – Lower Baker Dam

Lower Baker Dam is located at River Mile (RM) 1.2 on the Baker River tributary to the Skagit River, which comes into the Skagit River (RM 56.5) just upstream of the Concrete Gage. The drainage area above Lower Baker Dam is 297 square miles, of which, 82 square miles is between Upper and Lower Baker Dams which is an additional 3% of the drainage area and 15% combined for the Skagit River near Mount Vernon. With the existing flood control space and flow releases at Upper Baker Dam, Lower Baker Dam's combined existing outflow contribution to the 100-year flow is 16,500 cfs which represents 7.3% of the total flow (7,500 cfs is the runoff between Upper and Lower Baker Dam and 9,000 cfs is the release from Upper Baker). These measures are designed to reduce the flow contribution coming from Lower Baker Dam with storage and outflow adjustments.

The major advantage of this measure is that implementation can be carried out on an informal basis by Puget Sound Energy in appropriate flood events (case-by-case basis). Potential disadvantages include limited storage capacity, limited outflow capacity, and hydropower losses. In addition, new Corps HQ structure and design requirements must be met. Finally, the flood forecasting technology currently available does not allow for the sufficiently precise prediction of storm timing and magnitude that would be required for this project to be Federally authorized.

Measure 2A 1&2 – Lower Baker Dam – 15K Storage – 0 cfs Outflow

This measure would initiate flood control at Lower Baker Dam. This measure would set aside 15,000 acre-feet of storage for floods. In this evaluation, there is no way to maintain any storage by the time the peak flow occurs at Concrete using any conventional methods of flood control even for smaller events such as the 5-year and 10-year. This result is caused by two limitations. There is limited outflow capacity to maintain the storage (can only release 4000 cfs below the spillway crest), and the limited storage fills up with the excess inflow.

To define what is conventional, it is generally recognized that a set plan and storage needs to be in place before any flood occurs because, otherwise, the plan requires a very good understanding of the weather and its hydrologic response to act appropriately. An example of a set plan is what the Corps has with Upper Baker and that is that the Corps shuts flows down to minimum flows 3 hours before the unregulated (natural (without dam flow)) Skagit River near Concrete flow reaches 90,000 cfs and then reduces flows to 0 cfs until the flood peak passes and then begin to evacuate pool.

Considerations for further Study:

- Corps Headquarters will need to determine whether the dam meets current Corps operation and design requirements. If the dam does not meet criteria, Headquarters will need to identify what dam modifications are required and these costs will be attributed to the measure. This effort cannot be initiated until FERC determines what modifications may be required to the dam for Puget Sound Energy (PSE) to meet FERC requirements.
- Operation, as described, would require that the National Weather Service (NWS) could, with 90%+ certainty, forecast upcoming flood events' time, magnitude and duration to be sufficiently reliable for Corps authorization. Based on discussions with NWS, this is impossible.
- Costs to structurally modify the dam have not been determined or included in this evaluation. Dam maintenance and operation costs attributed to additional flood storage would be a 100% local cost.
- Costs of implementation of this measure are based strictly on hydropower loss from change in operations of the dam. Power loss compensation would be a 100% local cost.
- Potential environmental impacts have not been evaluated. Assurance that this measure would not impact critical in-stream flows (i.e. spawning beds and fish stranding) is needed.

Measure 2B 1&2 – Lower Baker Dam – 29K Storage – 0 cfs Outflow

This measure would initiate flood control at Lower Baker Dam. This measure would set aside 29,000 acre-feet of storage for floods. In this evaluation, there is no way to maintain any storage by the time the peak flow occurs at Concrete using any conventional methods of flood control even for smaller events such as the 5-year and 10-year. This result is caused by two limitations. There is limited outflow capacity to maintain the storage (can only release 4000 cfs below the spillway crest), and the limited storage fills up with the excess inflow.

To define what is conventional, it is generally recognized that a set plan and storage needs to be in place before any flood occurs because, otherwise, the plan requires a very good understanding of the weather and its hydrologic response to act appropriately. An example of a set plan is what we have with Upper Baker and that is that we shut flows down to minimum flows 3 hours before the unregulated (natural (without dam flow)) Skagit River near Concrete flow reaches 90,000 cfs and then reduce flows to 0 cfs until the flood peak passes and then begin to evacuate pool.

Considerations for further Study:

- Corps Headquarters will need to determine whether the dam meets current Corps operation and design requirements. If the dam does not meet criteria, Headquarters will need to identify what dam modifications are required and these costs will be attributed to the measure. This effort cannot be initiated until FERC determines what modifications may be required to the dam for Puget Sound Energy (PSE) to meet FERC requirements.

- Operation, as described, would require that the National Weather Service (NWS) could, with 90%+ certainty, forecast upcoming flood events' time, magnitude and duration to be sufficiently reliable for Corps authorization. Based on discussions with NWS, this is impossible.

- Costs to structurally modify the dam have not been determined or included in this evaluation. Dam maintenance and operation costs attributed to additional flood storage would be a 100% local cost.

- Power loss compensation would be a 100% local cost.

- Potential environmental impacts have not been evaluated. Assurance is needed that this measure would not impact critical in-stream flows (i.e. spawning beds and fish stranding).

Measure 2C 1&2 – Lower Baker Dam – 45K Storage – 0 cfs Outflow

This measure would initiate flood control at Lower Baker Dam. This measure would set aside 45,000 acre-feet of storage for floods. In this evaluation, there is no way to maintain any storage by the time the peak flow occurs at Concrete using any conventional methods of flood control even for smaller events such as the 5-year and 10-year. This result is caused by two limitations. There is limited outflow capacity to maintain the storage (can only release 4000 cfs below the spillway crest), and the limited storage fills up with the excess inflow.

To define what is conventional, it is generally recognized that a set plan and storage needs to be in place before any flood occurs because, otherwise, the plan requires a very good understanding of the weather and its hydrologic response to act appropriately. An example of a set plan is what we have with Upper Baker and that is that we shut flows down to minimum flows 3 hours before the unregulated (natural (without dam flow)) Skagit River near Concrete flow reaches 90,000 cfs and then reduce flows to 0 cfs until the flood peak passes and then begin to evacuate pool.

Considerations for further Study:

- Corps Headquarters will need to determine whether the dam meets current Corps operation and design requirements. If the dam does not meet criteria, Headquarters will need to identify what dam modifications are required and these costs will be attributed to the measure. This effort cannot be initiated until FERC determines what modifications may be required to the dam for Puget Sound Energy (PSE) to meet FERC requirements.
- Operation, as described, would require that the National Weather Service (NWS) could, with 90%+ certainty, forecast upcoming flood events' time, magnitude and duration to be sufficiently reliable for Corps authorization. Based on discussions with NWS, this is impossible.
- Costs to structurally modify the dam have not been determined or included in this evaluation. Dam maintenance and operation costs attributed to additional flood storage would be a 100% local cost.
- Power loss compensation would be a 100% local cost.
- Potential environmental impacts have not been evaluated. Assurance is needed that this measure would not impact critical in-stream flows (i.e. spawning beds and fish stranding).

Measure 3 – Ross Dam

Ross Dam is located at River Mile (RM) 105.20 on the Skagit River, which is just upstream of Newhalem. The drainage area above Ross Dam is 999 square miles which is roughly 32% of the drainage area for the Skagit River near Mount Vernon and would typically contribute roughly 18% of the peak flow seen on the Skagit River if there was no flood control. The Corps of Engineers currently has the authorization for flood control space that maximizes at 120,000 acre-feet on December 1st of the flood season. With the existing flood control space, Ross Dam outflow's current contribution to the 100-year flow is 10,500 cfs which represents 4.7% of the total flow. These measures are designed to reduce the flow contribution coming from Ross Dam with additional storage, timing, and minimum outflow adjustments.

The potential advantage of this measure is the reduction of flows for events greater than the 10-year event. Potential disadvantages include impacts to endangered species, hydropower losses, and impacts to Seattle City Light facilities. In addition, the measure would require re-opening of the FERC license, and might require negotiations with Canada.

Measure 3A – Ross Dam – 150K Storage – 0 cfs Outflow

This measure increases the flood storage set aside from 120,000 acre-feet to 150,000 acre-feet and sets the minimum flow released from Ross Dam to 0 cfs. The flood control follows what is set in the Water Control manual. This measure reduces the outflow at the dam for flood events greater than or equal to a 25-year event. This measure reduces flows for all events greater than a 10-year event at all locations.

Considerations for further Study:

- Seattle Public Utilities (SPU) is not supportive of modifying the operation or structure of their dams. Modifications could require a reopening of their FERC license and could impact their launch and other facilities. Increases in pool elevation would require international negotiations with Canada.
- Cost attributable to any changes in operation or maintenance, or hydropower losses would be funded 100% by the local sponsor.

- The estimate of benefits should be considered preliminary and are provided for the purpose of initial screening of management measures.
- Environmental impacts of modifications have not been identified.

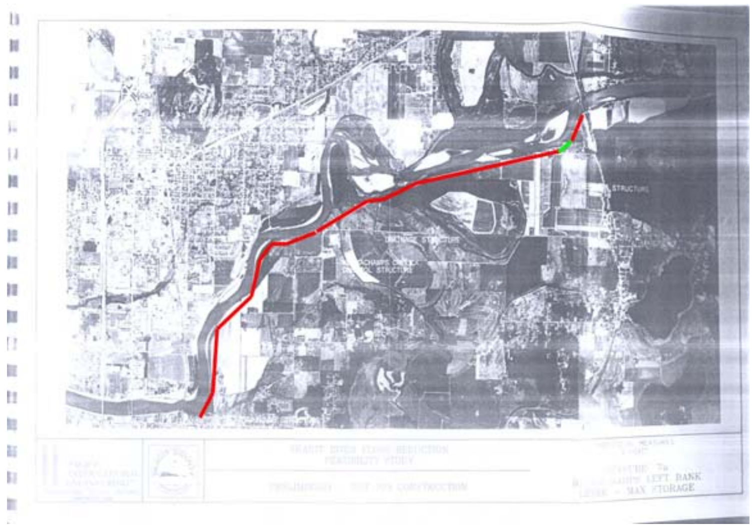
Measure 3B – Ross Dam – 180K Storage – 0 cfs Outflow

This measure increases the flood storage set aside from 120,000 acre-feet to 180,000 acre-feet and sets the minimum flow released from Ross Dam to 0 cfs. The flood control follows what is set in the Water Control manual. This measure reduces the outflow at the dam for flood events greater than or equal to a 25-year event. This measure reduces flows for all events greater than a 10-year event at all locations.

Considerations for further Study:

- Seattle Public Utilities (SPU) is not supportive of modifying the operation or structure of their dams. Modifications could require a reopening of their FERC license and could impact their launch and other facilities. Increases in pool elevation would require international negotiations with Canada.
- Cost attributable to any changes in operation or maintenance, or hydropower losses would be funded 100% by the local sponsor.
- Benefit estimates should be considered preliminary and are provided for the purpose of initial screening of management measures.
- Environmental impacts of modifications have not been identified.

Measure 4 – Nookachamps Storage



This measure attempted to follow the design and modeling provided by PIE in 2006. This design is a levee structure on the left bank from the Highway 9 bridge just downstream of Sedro-Woolley (River Mile (RM) 22.7) to the BNSF Bridge at the beginning of the three bridge corridor (RM 17.56). There is a gate at the upstream end that would control when the water entered into the storage area. The design of this measure has a gate that is 15 feet high and 300 feet wide and has an invert of 35 feet NGVD 29. The gate opens when the flow through the 3 bridge corridor approaches 140,000 cfs.

Table 8 presents damages by reach in the without-project condition, with Measure 4 in place, and damages prevented (benefits), calculated using HEC-FDA flood damage analysis software.

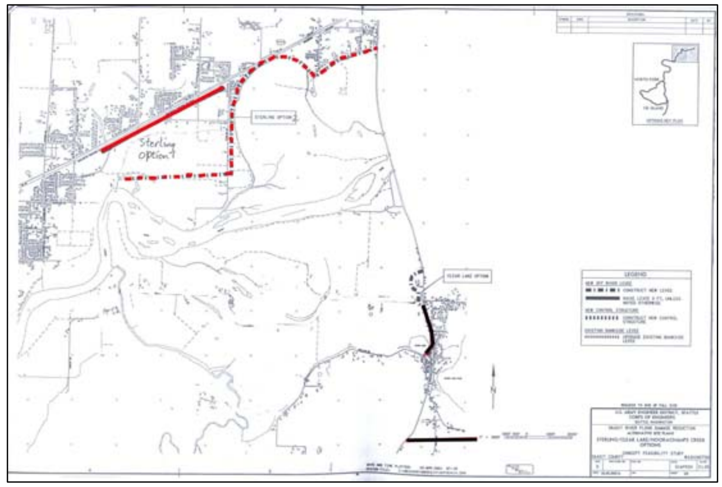
Measure 5 – Hart's Slough Storage

This measure attempted to follow the design and modeling provided by PIE in 2006. This design is a levee structure on the left bank from the Highway 9 bridge just downstream of Sedro-Woolley (River Mile (RM) 22.7) to the start of the levee system at RM 21.6. There is a gate at the upstream end that would control when the water entered into the storage area. The design of this measure has a gate that is 15 feet high and 170 feet wide and has an invert of 35 feet NGVD 29. The gate opens when the flow through the 3 bridge corridor approaches 140,000 cfs.

Table 9 presents damages by reach in the without-project condition, with Measure 5 in place, and damages prevented (benefits), calculated using HEC-FDA flood damage analysis software.

Measure 6 – Sterling Levee

This levee is designed to plug up the low spot in the Highway 20 and railroad that is found on the right bank at roughly RM 21.9 where the ground elevation dips to 39.9 feet NGVD 29. This elevation corresponds to roughly a 10-year flood elevation so any floods larger than a 10-year flood (125,000 cfs) allows water to overflow in this area and eventually makes its way into Burlington. This area has been flood fought in the past but this measure would make the structure more permanent.



There were two designs for this levee developed in 2001 that are shown in the picture above. One of them ties in the levee at the upstream side at Sedro-Woolley and the downstream side at the existing levee system. It also encompasses most of the houses that are found in this area. The other design raises the ground elevation for the low spot only to match what is upstream and downstream.

Major potential advantages for this measure are that it will be considered in conjunction with a large levee system during alternatives analysis, and that the addition of an optional setback would have less environmental impacts. Potential disadvantages include a lack of significant flood protection as a stand-alone project, lack of completed environmental impacts analysis, possibility of relocation requirements with the setback option, and that sub-measure 6B is limited to protection between 10- and 20-year events.

Considerations for further Study:

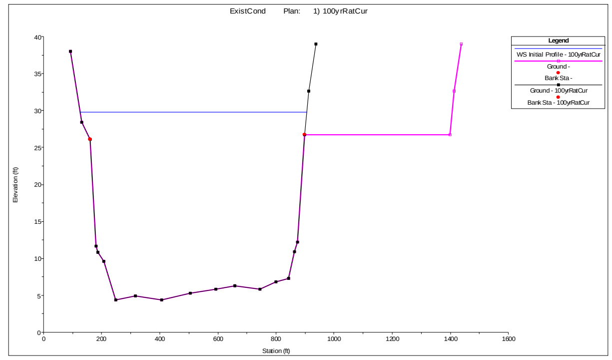
- This measure will be considered in conjunction with a larger levee system during alternatives analysis. It does not provide significant flood protection as a stand-alone project.
- This measure does not represent protection by itself, but is tied to the protection downstream. There is some benefit to filling in the low spot (not yet quantified). However, in the analysis, the results would only appear for events above a 10-year, and below a 20-year probability. In the levee failure analysis that has been completed, additional levees fail beyond a 20-year event, making it difficult to distinguish between the flooding caused by overtopping, and the flooding

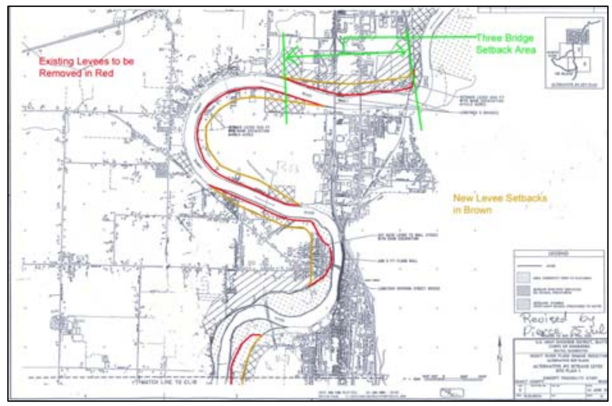
caused by other levee failures that contribute water to this same area. A detailed analysis of only this levee is possible, but may not be pragmatic. Unless the Sterling Levee is the only other chosen measure, the analysis may not be warranted. It is best at this time to tie this levee to Measure 15 - Improve Levee System – Right Bank.

- The environmental impacts of this measure have not been evaluated.

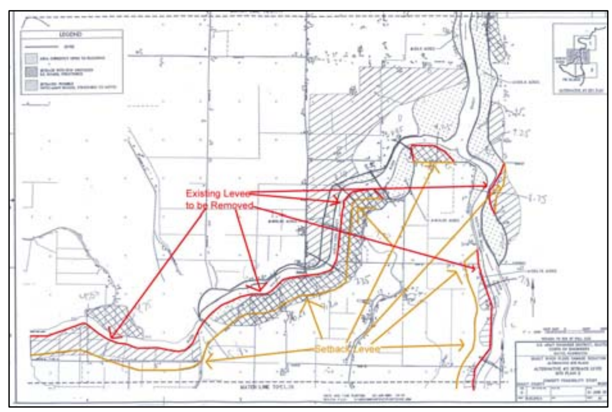
Measure 7 – Levee Setback - Downstream of 3-Bridge Corridor

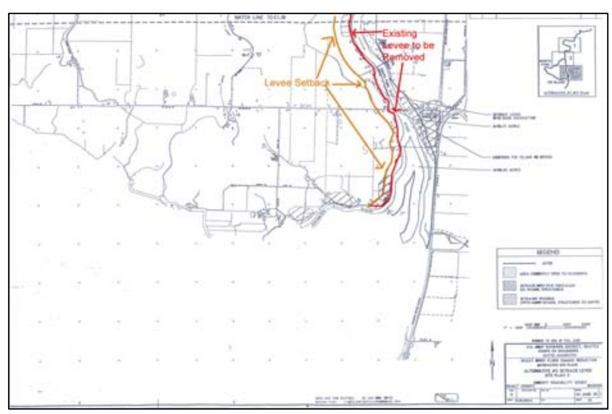
This setback is designed to improve the levee system's ability to move more water downstream by giving the river more area to move downstream. This setback starts just downstream of the I-5 bridge (RM 16.8) and extends out both the North and South Forks. The setback starts below the three-bridge area to see what the benefit is without having to expensively rebuild the three bridges. The Mount Vernon Bridge would still need to be set back as well as the North Fork and South Fork bridges. The picture shows the existing cross section with the black dots and the revised setback cross section in pink. The next three pictures show the plan view with the setback including everywhere but the area in green.





This measure is a 500 foot setback on the Mainstem from RM 16.8 to the Forks, the North Fork from the Mainstem to its mouth, and the South Fork from the Mainstem to its mouth. The setback starts at the top of bank elevation and the levee is moved back 500 feet from where it currently is. The setback alternates which side of the bank it is on based on a preliminary look at where the real estate would be cheaper to obtain. This layout is as follows:





<u>Mainstem</u>

Left Bank – RM 16.8 to 13.8

Right Bank – RM 13.8 to 11.7

Left Bank – RM 11.7 to Forks

<u>North Fork</u>

Left Bank – RM 9.25 to mouth

<u>South Fork</u>

Left Bank – RM 9.25 to 7.8

Right Bank – RM 7.8 to mouth

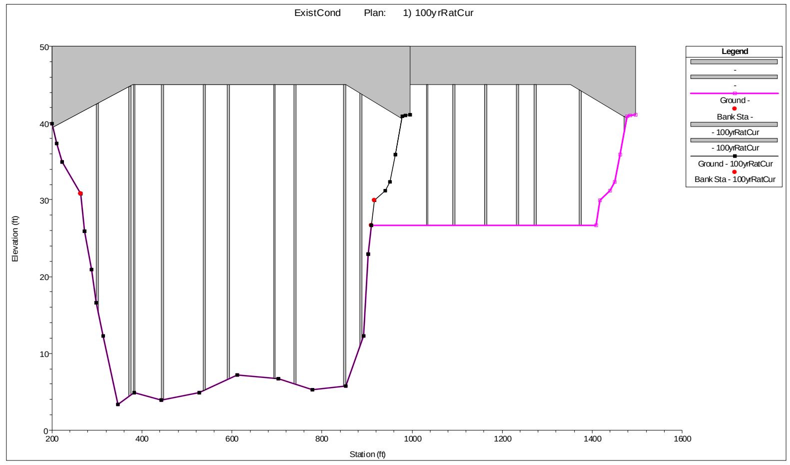
Potential advantages of this measure include the reduction of induced flooding and required levee height, as well as the minimization of environmental impact and the provision of riparian improvement opportunities. Potential disadvantages include the necessary modifications to bridges (Mount Vernon, North Fork, and South Fork), the difficulty of raising a levee on only one side of the river (induced flooding), increased sediment transport, increased localized flooding, impacts to agricultural land, and potential toxic contamination. Also, the measure will require purchasing of property (relocation) and replacement of existing infrastructure (i.e. West Mount Vernon).

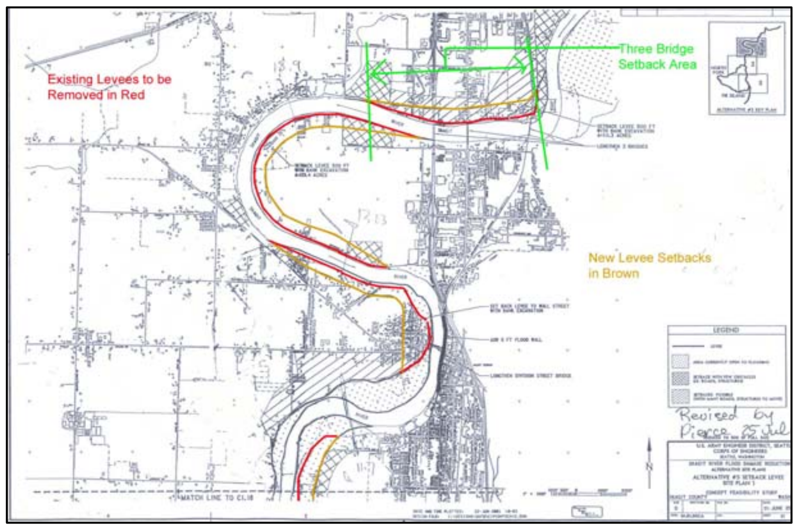
Consideration for further study:

- At this time, this measure has only been run with the levee setback elevations being the same as the existing levee elevations. This is partly because the improvement alternates from one side of the river to the other. It would be difficult to raise one side and not the other, particularly when it is not connected all the way from upstream to downstream. Running a setback levee all on the same side will alter the costs of the measure.
- Environmental impacts have not been evaluated. However, setting back levees generally minimizes environmental impact.

Measure 8 – Levee Setback – Three Bridge Corridor Only

This setback is designed to improve the levee system's ability to move more water downstream past the three bridge corridor by giving the river more area to move in this area. This setback starts at the BNSF RR bridge (RM 17.56) and ends just downstream of the I-5 bridge (RM 16.8). This setback is designed to determine the benefit of the setback just at the three bridge area. This involves the replacement of the BNSF RR bridge, the Riverside bridge, and the I-5 Bridge. The picture below shows the existing cross section with the black dots and the revised setback cross section in pink. The next picture below shows the plan view of the setback in the green area.





This measure is a 500 foot setback on the Mainstem right bank from RM 17.56 to 16.8. The setback starts at the top of bank elevation and the levee is moved back 500 feet from where it currently is. The setback alternates which side of the bank it is on based on a preliminary look at where the real estate would be cheaper to obtain. This layout is as follows:

<u>Mainstem</u>
Right Bank – RM 17.56 to 16.8

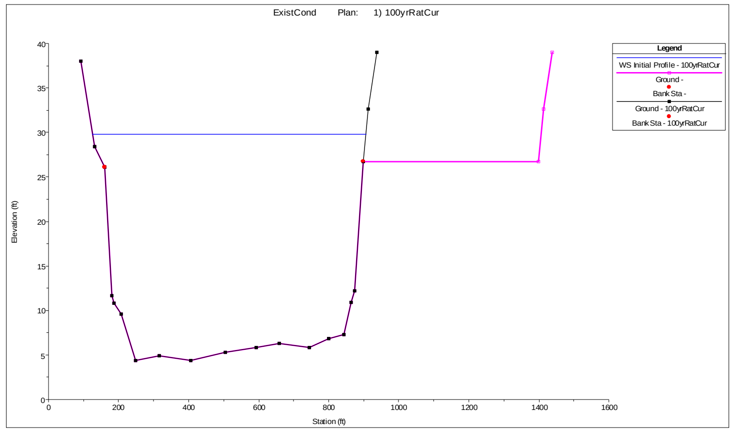
Potential advantages of this measure include the reduction of flooding upstream of the 3-Bridge Corridor, minimization of environmental impact, opportunities for riparian improvements, and indirect reduction of debris management issues through bridge modifications. Potential disadvantages include the necessity of bridge modifications, Hwy 99 abutments replacements, the possibility of worsening downstream flooding, and the real estate purchasing requirements for setbacks (relocations, road/infrastructure replacement). In addition, bridge modifications would be the responsibility of

WSDOT and BNRR, but a Corps project must “stand on its own”. It would be invalid to assume that bridges would be modified in time for the Corps project.

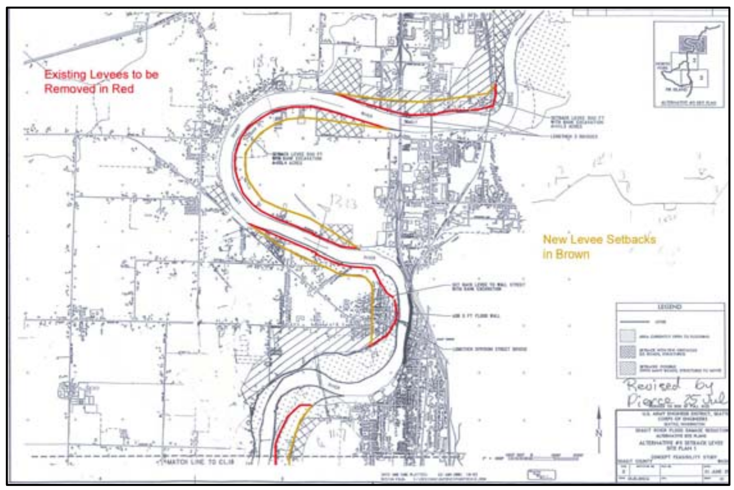
Consideration for further study:

- Elimination of river constriction will require significant modifications to the three bridges.
- At this time, this measure has only been run with the levee setback elevations being the same as the existing levee elevations. This is partly because the improvement alternates from one side of the river to the other. It would be difficult to raise one side and not the other, particularly when it is not connected all the way from upstream to downstream. Running one side only will alter the costs of the measure.
- Environmental impacts have not been evaluated. However, setting back levees generally minimizes environmental impact.

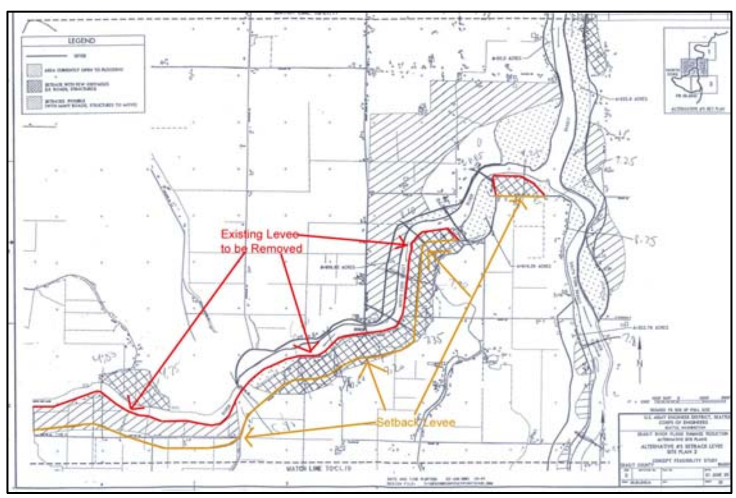
Measure 10 – Setback Levees Mainstem and North Fork Only



This setback is designed to improve the levee system's ability to move more water downstream by giving the river more area to move downstream. This setback starts at the beginning of the three bridge corridor at the BNSF Bridge (RM 17.56) to where the mainstem splits into the North and South Forks and then extends out the North Fork. The setback only extends down the North Fork to see whether the North Fork is the main downstream constriction of the two forks. This requires setting back 5 bridges. The picture below shows the existing cross section with the black dots and the revised setback cross section in pink. The next 2 pictures below show the plan view of the setback.



This measure is a 500 foot setback on the Mainstem from RM 17.56 to the Forks and the North Fork from the mainstem to its mouth. The setback starts at the top of bank elevation and the levee is moved back 500 feet from where it currently is. The setback alternates which side of the bank it is on based on a preliminary look at where the real estate would be cheaper to obtain. This layout is as follows:



<u>Mainstem</u>

Left Bank – RM 17.56 to 13.8

Right Bank – RM 13.8 to 11.7

Left Bank – RM 11.7 to Forks

North Fork

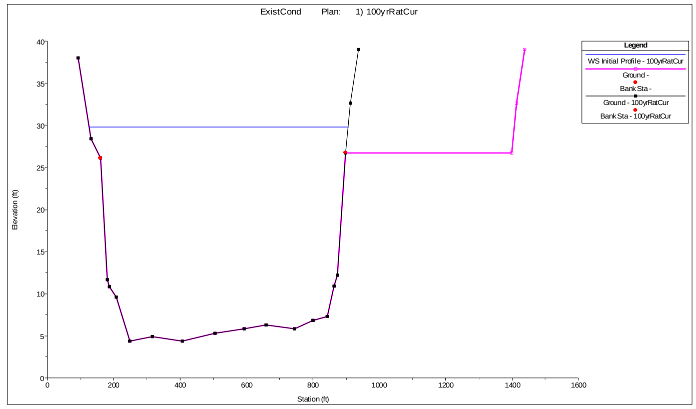
Left Bank – RM 9.25 to mouth

Potential advantages of this measure include the reduction of induced flooding, the minimization of environmental impacts, and the opportunity for riparian improvements. Potential disadvantages include the required setback of five bridges, increased sediment transport, localized erosion, relocation requirement, and the difficulty in raising a levee on only one side of the river. In addition, Corps policy does not support projects that encourage development in rural areas. Lastly, large property purchases and infrastructure replacement would be necessary.

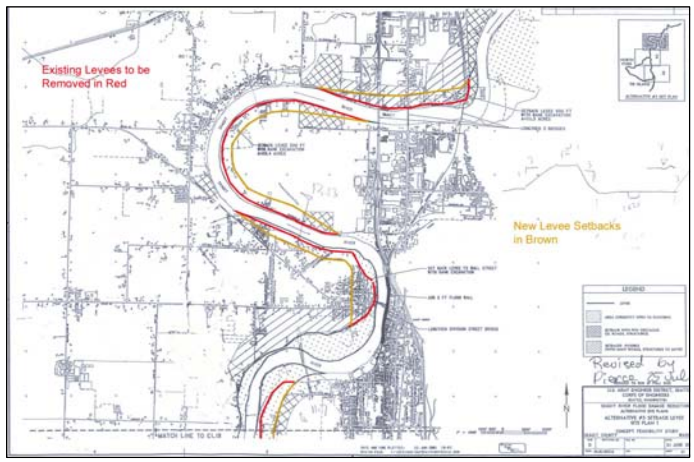
Consideration for further study:

- At this time, this measure has just been run with the levee setback elevations as the same as the existing levee elevations. This is partly because the improvement alternates from one side of the river to the other. It would be difficult to raise one side and not the other, particularly when it is not connected all the way from upstream to downstream. Running it with a levee only on one side will alter the costs of the measure.
- Environmental impacts have not been evaluated. However, setting back levees generally minimizes environmental impact.

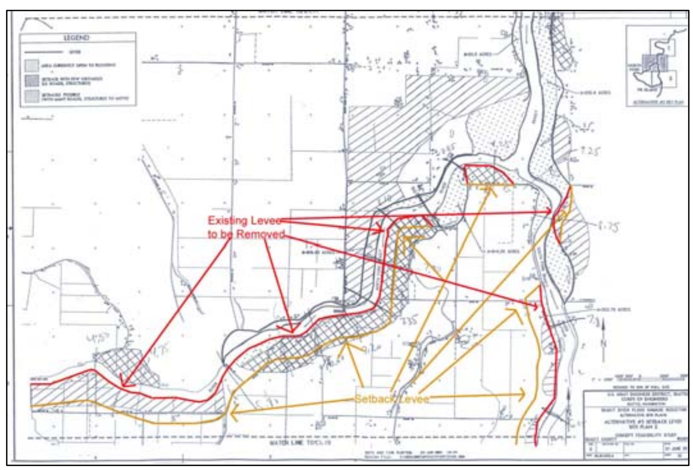
Measure 13 – Setback Levees – Entire System



This setback is designed to improve the levee system's ability to move more water downstream by giving the river more area to move downstream. This setback starts at the beginning of the three bridge corridor at the BNSF Bridge (RM 17.56) to where the mainstem splits into the North and South Forks and then extends out both the North Fork and South Fork Skagit River. This requires setting back 5 bridges. The picture below shows the existing cross section with the black dots and the revised setback cross section in pink. The next 3 pictures below show the plan view of the setback.



This measure is a 500 foot setback on the Mainstem from RM 17.56 to the Forks, the North Fork from the mainstem to its mouth, and the South Fork from the mainstem to its mouth. The setback starts at the top of bank elevation and the levee is moved back 500 feet from where it currently is. The setback alternates which side of the bank it is on based on a preliminary look at where the real estate would be cheaper to obtain. This layout is as follows:



Mainstem

Left Bank – RM 17.56 to 13.8

Right Bank – RM 13.8 to 11.7

Left Bank – RM 11.7 to Forks

North Fork

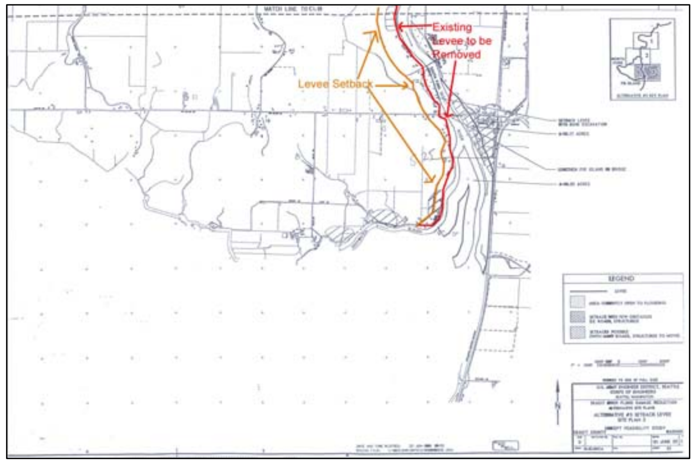
Left Bank – RM 9.25 to mouth

South Fork

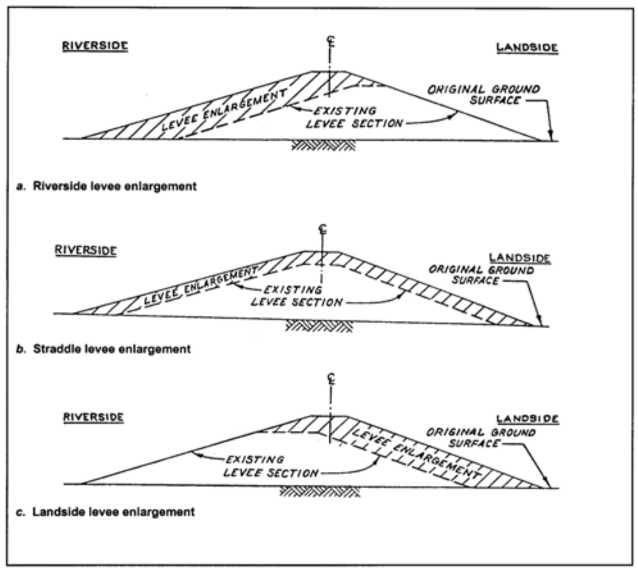
Left Bank – RM 9.25 to 7.8

Right Bank – RM 7.8 to mouth

Potential advantages of this measure include the reduction of induced flooding, the minimization of environmental impacts, and the opportunity for riparian improvements. Potential disadvantages include Corps policy on not supporting encouragement of rural development, setback of 5 bridges, increased sediment transport, increased localized erosion, and the difficulty in raising a levee on only one side of the river. In addition, the measure would require property purchased for a wider levee footprint and replacing large portion of existing infrastructure.



Considerations for further study:

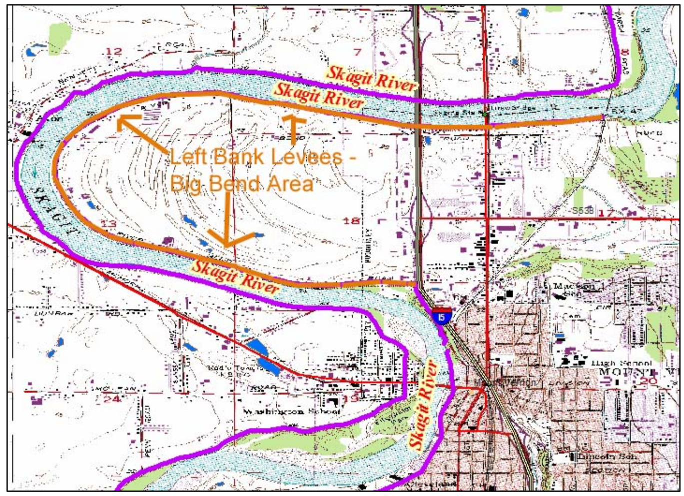


- At this time, this measure has only been run with the levee setback elevations at the same elevation as the existing levee elevations. This is partly because the improvement alternates from one side of the river to the other. It would be difficult to raise one side and not the other, particularly when it is not connected all the way from upstream to downstream. Running a setback levee with it all on one same side will alter the costs of the measure.
- Environmental impacts have not been evaluated. However, setting back levees generally minimizes environmental impact.

Measure 14 – Improve Levee System – Left Bank

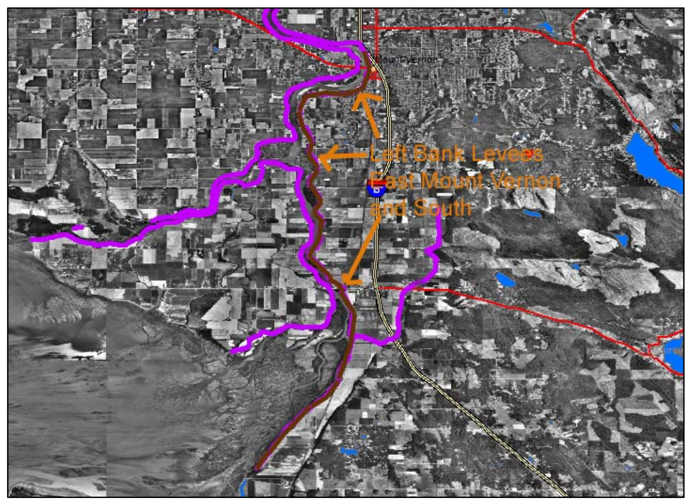
This improvement of existing levee measure is evaluating the benefits of raising the left bank levee system that protects the North Mount Vernon area (RM 17.56 to RM 13.1) as well as from East Mount Vernon south to Stanwood (RM 13.1 to the mouth of the South Fork).

The major potential advantage of this measure is the minimal change in footprint versus a setback levee. Potential disadvantages include violation of Corps policy and Executive Order 11988, requirement to improve entire system, mitigation requirement for environmental impacts, increased sedimentation and localized erosion, and the difficulty in raising a levee on only one side of the river.



Measure 14A – Improve Existing Levees – Left Bank - Remove All Damages

This measure looks at removing all damages from the North Mount Vernon area (RM 17.56 to RM 13.1) and East Mount Vernon south to Stanwood (RM 13.1 to the mouth of the South Fork). This encompasses reaches 4, 4A, 5 and 5A.



Consideration for further study:

- This is a hypothetical measure which assumes all damaged can be prevented. It is used as a baseline comparison in determining damages prevented among the various measures.

Measure 14B – Improve Existing Levees – Left Bank - Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from areas behind levees when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood in the North Mount Vernon area (RM 17.56 to RM 13.1) and East Mount Vernon south to Stanwood (RM 13.1 to the mouth of the South Fork). This encompasses reaches 4, 4A, 5 and 5A.

Consideration for further study:

- Environmental impacts have not been evaluated. This measure could have impacts on riverine habitat.

Measure 14C – Improve Existing Levees – Left Bank – Big Bend Area Only - Remove All Damages

This measure looks at removing all damages from the North Mount Vernon area (RM 17.56 to RM 13.1). This encompasses reaches 5 and 5A.

No analysis of damages prevented has been completed. No project cost estimate has been completed.

Consideration for further study:

- This is a hypothetical measure which assumes all damaged can be prevented. It is used as a baseline comparison in determining damages prevented among the various measures.

Measure 14D – Improve Existing Levees – Left Bank – Big Bend Area Only - Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from areas behind levees when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood in the North Mount Vernon area (RM 17.56 to RM 13.1). This encompasses reaches 5 and 5A.

No analysis of damages prevented has been completed. No project cost estimate has been completed.

Consideration for further study:

- This measure protects a largely undeveloped area within the bend. Corps regulations prohibit constructing projects that encourage development. Therefore, the preferred alignment for a levee in this area is adjacent to the highway. This would also retain an area for natural valley storage.
- Environmental impacts have not been evaluated. This measure could have impacts on riverine habitat.

Measure 14E – Improve Existing Levees – Left Bank – East Mount Vernon and South Only - Remove All Damages

This measure looks at removing all damages from the East Mount Vernon south to Stanwood (RM 13.1 to the mouth of the South Fork). This encompasses reaches 4 and 4A.

No analysis of damages prevented has been completed. No project cost estimate has been completed.

Consideration for further study:

- This is a hypothetical measure which assumes all damaged can be prevented. It is used as a baseline comparison in determining damages prevented among the various measures.

Measure 14F – Improve Existing Levees – Left Bank – East Mount Vernon and South Only - Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

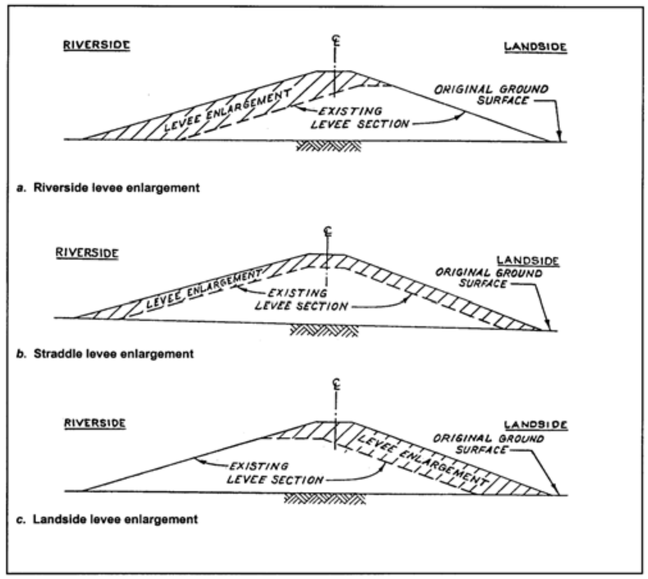
This measure looks at removing damages from areas behind levees when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood in the East Mount Vernon south to Stanwood (RM 13.1 to the mouth of the South Fork). This encompasses reaches 4 and 4A.

No analysis of damages prevented has been completed. No project cost estimate has been completed.

Consideration for further study:

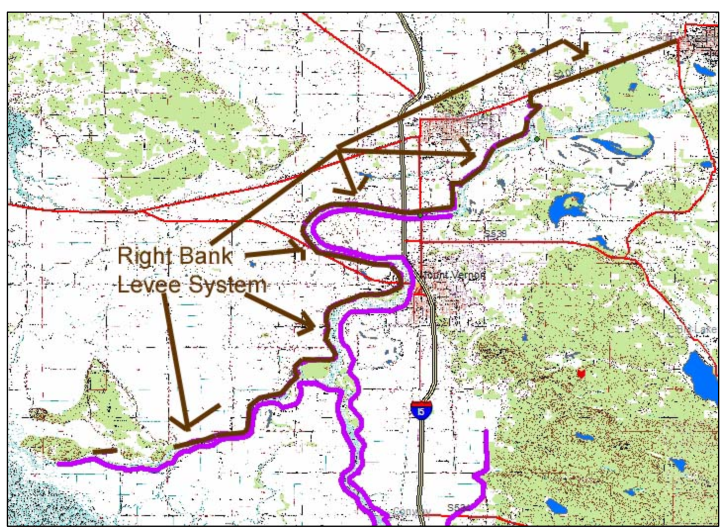
- Environmental impacts have not been evaluated. This measure could have impacts on riverine habitat.

Measure 15 – Improve Levee System – Right Bank



The improve right bank existing levee measure is evaluating the benefits of raising the levee system that protects the right bank of the Skagit River from Highway 9 (RM 22.7) to the mouth of the North Fork Skagit River. The right bank existing levee system on the Mainstem starts at RM 20.9 and is continuous through the North Fork right bank except for minor sections on the right bank of the North Fork where there are parts that are tied to high ground. The costs for this design are derived from PIE's Interim Evaluation of Measures Report (April 2006) by combining elements Sterling Levee (page 105), Right bank Levee Highway 9 (Rhodes Road) to BNSF Bridge (page 111), 3a – DD12 Right Bank River Bend Setback Levee (page 131), 3b - River Bend Setback Levee (page 131), 5b - Mount Vernon Right Bank Levee (page 191), 5c - Mount Vernon Right Bank Levee (page 191), 10b – DD1 – Right Bank Levee RM 12 to Fork (page 191), and North Fork Right Bank Levee (page 247).

Measure 15A – Improve Existing Levees – Right Bank - Remove All Damages



This measure looks at removing all damages from right bank of the Skagit River from Highway 9 (RM 22.7) to the mouth of the North Fork Skagit River. This encompasses reaches 1, 1A, 2, 2A, and 7.

Potential advantages of this measure include minimal changes in levee footprint versus a setback levee, and that the measure will be considered in conjunction with a large levee system during alternatives analysis. Potential disadvantages include Corps policy to not encourage development in rural areas, requirement to improve entire levee system, significant maintenance requirements, significant mitigation for environmental impacts, increased sedimentation and localized erosion, induced flooding, and the difficulty in raising a levee on only one side of the river.

Consideration for further study:

- This is a hypothetical measure which assumes all damaged can be prevented. It is used as a baseline comparison in determining damages prevented among the various measures.

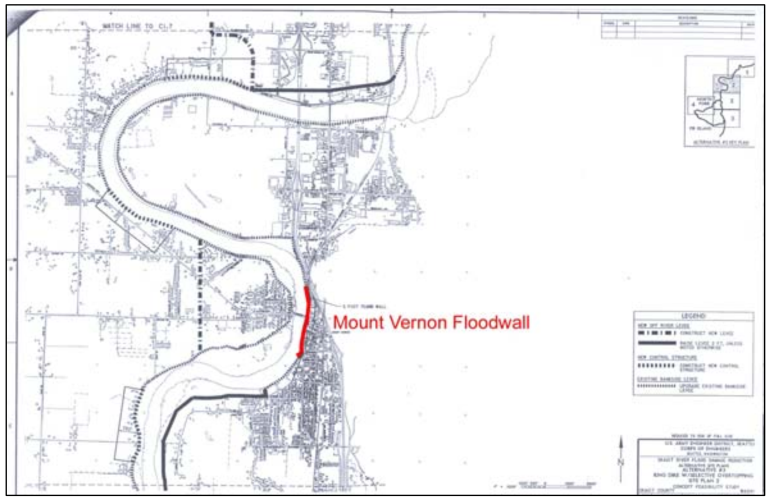
Measure 15B – Improve Existing Levees – Right Bank - Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from areas behind levees when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood on the right bank of the Skagit River from Highway 9 (RM 22.7) to the mouth of the North Fork Skagit River. This encompasses reaches 1, 1A, 2, 2A, and 7.

Considerations for further study:

- Environmental impacts have not been evaluated. This measure could have impacts on riverine habitat.

Measure 16 – Mount Vernon Floodwall



The Mount Vernon Floodwall is a design to reduce damages to downtown East Mount Vernon by building a floodwall to eliminate the low spot that is currently sandbagged during floods. This evaluation has similar challenges as the Sterling Levee in that it is difficult to quantify damages

The Mount Vernon Floodwall is designed to plug up the low spot on the left bank at East Mount Vernon (RM 12.96) to RM 12.4. This area is currently sandbagged during floods and has a rough ground elevation of 28 to 29 feet NGVD 29 which corresponds to roughly a 10-year water surface (120,000 cfs). Floods larger than a 10-year flood, therefore, could allow water to overflow into downtown East Mount Vernon if the area was not sandbagged. This measure would make the structure more permanent.

The design for this floodwall developed in 2001 is shown in the picture above. The design raises the ground elevation for the low spot only to match what is upstream and downstream.

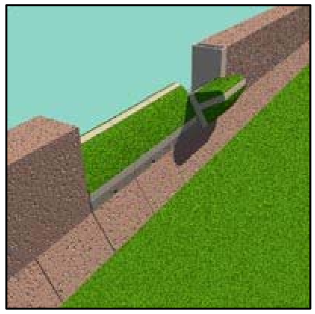
Potential advantages of this measure include a permanent feature to reduce damages in East Mount Vernon (replace annual flood fighting), and the minimization of impacts to structures adjacent to the river, compared to a levee. Potential disadvantages include lack of significant flood protection as a stand-alone project, impacts to commercial structures (i.e. parking), restriction of public access to the river, and the need to assess impacts on historic buildings.

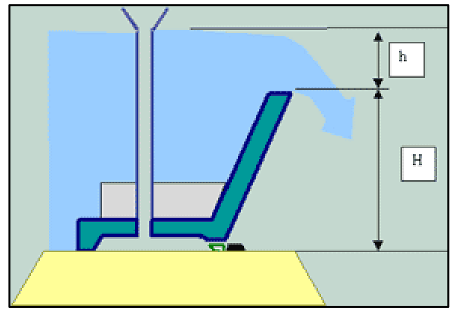
Considerations for further study:

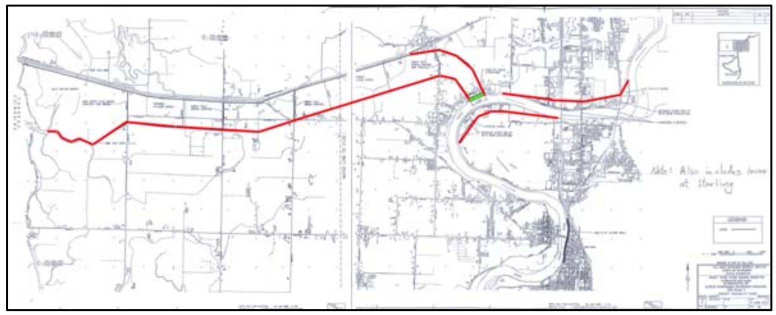
- This measure could impact Mount Vernon commercial structures near the river. Possible induced flooding will need to be evaluated and mitigated.
- The challenge with this measure is that it does not represent protection by itself, but is tied to the protection upstream and downstream. There is a benefit to filling in the low spot but, in the analysis, the results would only appear between a 10-year event and a 25-year event. In the levee failure analysis that was completed, some additional levees fail beyond a 25-year event and so it becomes difficult to distinguish the flooding being caused by this overtopping and the

flooding caused by levees failing that contribute water to this same area. This analysis can be done but would take some extensive analysis that may not be worth it unless we plan to only do the Mount Vernon Floodwall at a minimal protection level and not do anything else. It is best at this time to extend this floodwall and make it a ring dike as is done in Measure 35 – East Mount Vernon Ring Dike.

Measure 17 - Swinomish Bypass

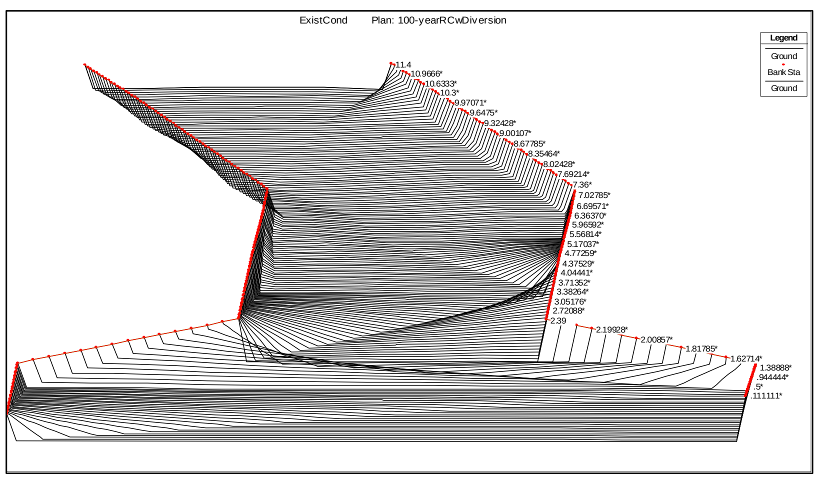






The Swinomish Bypass is a design to divert water out to the Swinomish Channel to Padilla Bay through a fusegate “designed fail” system where the levee would fail at a specific elevation and location and then this overflow would be leveed in down to the Swinomish Channel. The Bypass would be 6.7 miles long. This also requires a setback of the levee in the three-bridge corridor to get the flow through to the bypass.

The Swinomish Bypass design diverts water at the end of the first river bend past the three bridge corridor (RM 15.9). The fuseplugs would be designed to start failing at a water surface of 34.5 feet NGVD 29. They fail in 200 foot increments with the second failing at 34.7 feet NGVD 29 and the third at 34.9 feet NGVD 29. This measure maxes out at 600 feet wide. The 34.5 feet elevation is the elevation of the 25-year existing condition water surface in the average levee failure condition. The water that spills out is contained in a 2000 foot wide corridor with levees on both sides and expanding to 5000 feet for the last 1.5 miles down by the Swinomish Channel. No excavation is done in this measure on the route to the Swinomish Channel. The design currently is for the area to be maintained during the winter in a way that keeps the roughness of the channel down. The setback of the levee in the three-bridge corridor is 500 feet.

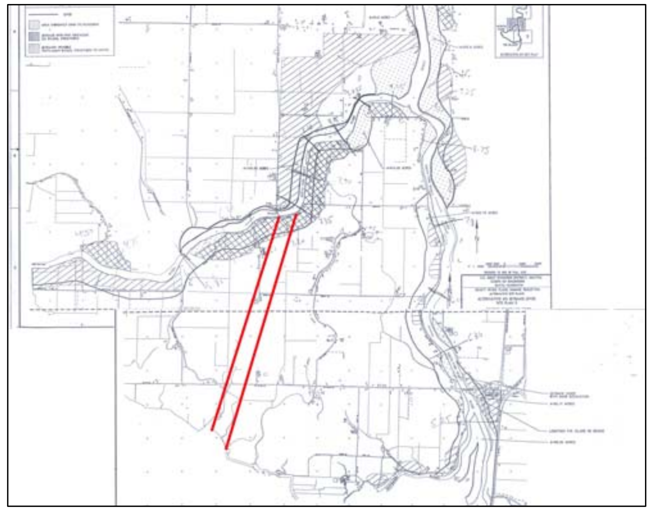


Potential advantages of this measure include the lack of catastrophic failure risk, and the added potential for recreation and/or environmental features. Potential disadvantages include sediment deposition into Padilla Bay (a marine sanctuary), localized erosion, impacts to Swinomish Slough, impacts to agricultural land, and required evaluation of setting weir elevation to a 5 to 10-year event. In addition, benefits will not be fully realized until 3 bridges are replaced.

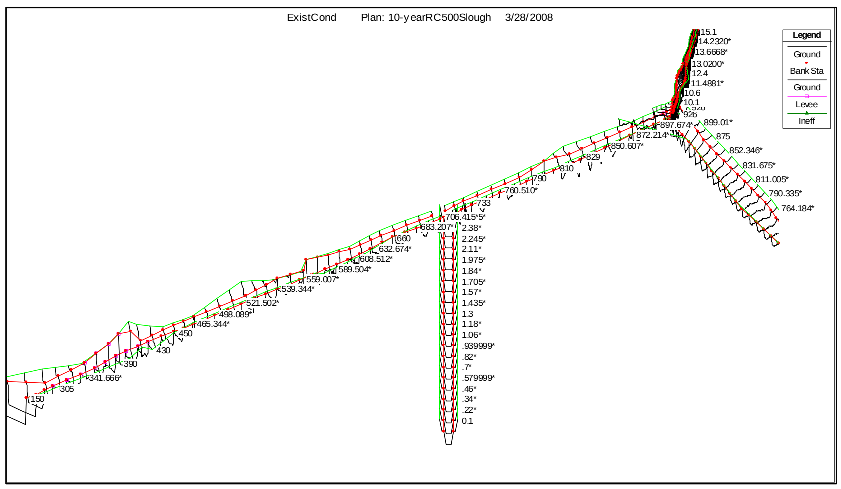
Considerations for further study:

- This measure does not realize its full benefit because the bypass does not become effective until water is already high enough on the levees that it can cause failures. The economic analysis sees these river stages and equates the damages that can be seen when failures occur. It is also unlikely that necessary freeboard (to make the levee system certifiable) will be available if we wait this late to have the levee fail into the diversion. We probably want to look at allowing this diversion to become effective several feet lower.
- Environmental impacts have not been evaluated. Potential concerns include impacts to the Swinomish Channel and Padilla Bay.

Measure 18 – Fir Island Bypass



The Fir Island Bypass is a design to divert water from the North Fork Skagit River out to Skagit Bay. This is an excavated channel from a location on the North Fork Skagit River to Skagit Bay. This design is to help with overcoming the limited capacity of the North Fork Skagit River to convey flow to Skagit Bay. The location chosen is done to minimize movement of known residences, creation of new bridges, and length of the bypass. The bypass is 2.7 miles long and would require new bridges on Moore Road and Fir Island Road.



Potential advantages of this measure include a lack of catastrophic failure risk, the potential for environmental or recreational features, added environmental complexity to delta, no induced flooding, reduced flooding in Mount Vernon, and has a wider channel with levees as an option. Potential disadvantages of this measure include diversion of sediment to the central portion of the Skagit Bay shoreline, impacts to agricultural land, infrastructure improvement requirements, lack of economic justification as a stand-alone project, relocation requirements, and potential impacts to eelgrass beds.

Measure 18A – Fir Island Bypass – 500 feet

The Fir Island Bypass is a design to divert water from the North Fork Skagit River out to Skagit Bay at RM 7.2 of the North Fork. The bypass channel starts with a thalweg elevation that mimics RM 7.2 of the North Fork (-10 feet NGVD 29) and exits into Skagit Bay with a thalweg elevation of -20 feet NGVD 29. This measure's bypass is 500 feet wide. The design currently is for the area to be maintained during the winter in a way that keeps the roughness of the channel down.

Considerations for further study:

- There is a potential concern to the loss of farmland.
- Design would require replacement of bridge(s).
- There is a potential benefit from creating fresh water flow to the Skagit Estuary.

Measure 18B – Fir Island Bypass – 1500 feet

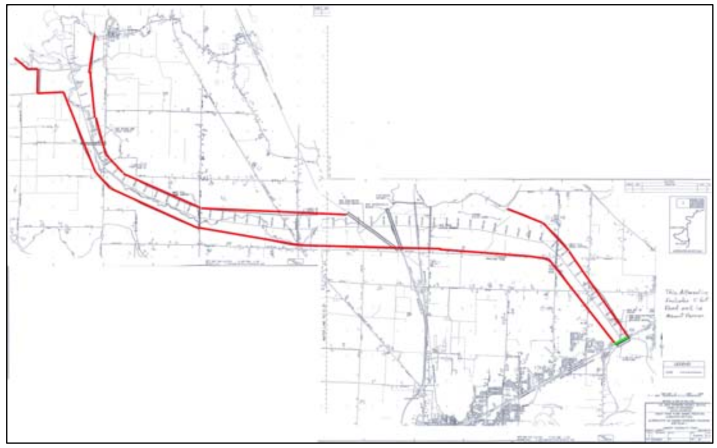
The Fir Island Bypass is a design to divert water from the North Fork Skagit River out to Skagit Bay at RM 7.2 of the North Fork. The bypass channel starts with a thalweg elevation that mimics RM 7.2 of the North Fork (-10 feet NGVD 29) and exits into Skagit Bay with a thalweg elevation of -20 feet NGVD 29. This measure's bypass is 1500 feet wide. The design currently is for the area to be maintained during the winter in a way that keeps the roughness of the channel down.

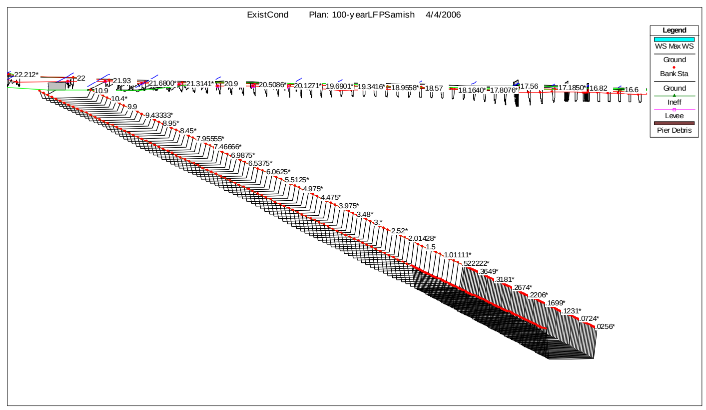
Considerations for further study:

- There is a potential concern to the loss of farmland.
- Design would require replacement of bridge(s).
- There is a potential benefit from creating fresh water flow to the Skagit Estuary.

Measure 19 – Samish Bypass

The Samish Bypass is a design to divert water out of the system before the river reaches the three bridge corridor. This bypass takes water out of the system at the northernmost point of Hart's Slough at RM 22.0.





The bypass goes north of the city of Burlington and follows the Samish River out to Samish Bay. This route is roughly 11 miles long and would require 9 bridges (Collins Road, District Line Road, Sheen Road, Burlington Alder Road, I-5, BNRR, Chuckanut Drive, Thomas Road, Farm to Market Road).

The Samish Bypass design diverts water at the northernmost point of Hart's Slough at RM 22.0 into a 1500 foot wide corridor with levees on both sides. No excavation is done in this measure on the route to Samish Bay. The entrance to the corridor is at 40.5 feet NGVD 29 which would start taking in water at floods slightly larger than a 10-year flood. The design currently is for the area to be maintained during the winter in a way that keeps the roughness of the channel down.

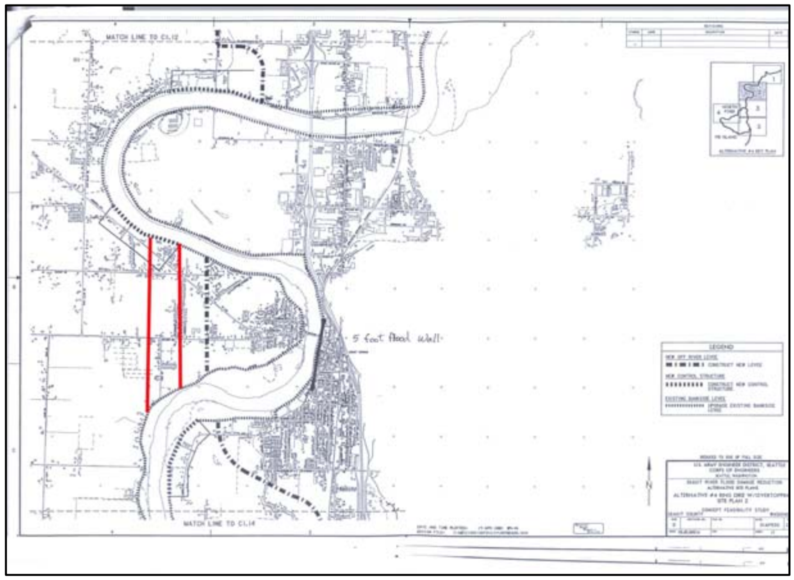
Potential Advantages of this measure include lack of catastrophic failure risk, potential for added recreation and/or environmental features, and removal of water upstream of the 3-bridge corridor. Potential disadvantages of this measure include the required construction (9 bridges, levees, excavation), weir height evaluation requirement, Samish basin impact analysis requirement, environmental impact analsyis requirement, impacts from cross-basin fish mixing, impacts to agricultural land, and diversion of fine sediments to Samish Bay during flood events.

Considerations for future study:

- This is the only measure that removes flow from the Skagit upstream of the Three Bridge Corridor. This measure will need to evaluate induced flooding to the Samish River system.
- This measure has challenges in showing major benefits because the bypass does not become effective until water is already high enough on the levees that it can cause failures. The economic analysis sees these river stages and equates the damages that can be seen when failures occur. The initial bypass grade is not very favorable to move a lot of flow. To make it more effective, a lot of excavation in this upper reach is probably necessary.
- Environmental impacts have not been evaluated. A potential issue is the cross basin mixing of the Skagit and Samish Rivers and resulting impacts on fish.

Measure 20 – Mount Vernon Bypass

The Mount Vernon Bypass is a design to overcome the constriction of the Skagit River at the Division Street Bridge. This increases conveyance in this area by creating an additional channel from upstream of West Mount Vernon at RM 14.0 to downstream at RM 11.2 (see picture below). This bypass is 1 mile long and requires two bridges at Highway 536 (Memorial Highway) and McLean Road.



Potential advantages of this measure include reduction of flood elevations near Mount Vernon, elimination of catastrophic failure risk, potential for added recreation and/or environmental features, minimization of environmental impact, and opportunity for riparian improvements. Potential disadvantages include infrastructure modification requirements, relocation requirements, loss of urban land, downstream sediment deposition, erosion, and possible levee improvements downstream of outlet. In addition, the measure may need to be combined with another to minimize the impacts to Fir Island.

Measure 20A – Mount Vernon Bypass – 500 feet

The Mount Vernon Bypass is an excavated channel that has a thalweg that is in between the thalwegs seen on the Skagit River at RM 14.0 and that of the Skagit River at RM 11.2 downstream (-5 feet NGVD 29). This measure's bypass is 500 feet wide.

Considerations for future study:

- These benefits should be considered preliminary and are provided for the purpose of initial screening of management measures.
- Environmental impacts have not been evaluated.
- Costs have not been evaluated.

Measure 20B – Mount Vernon Bypass – 1500 feet

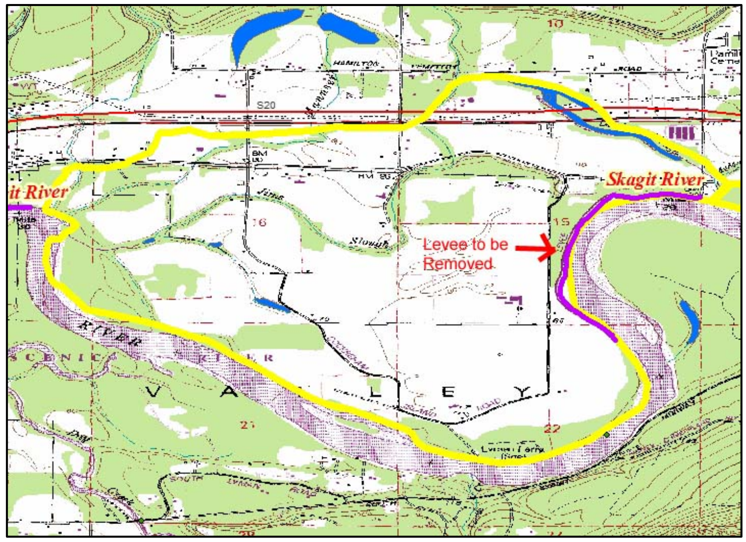
The Mount Vernon Bypass is an excavated channel that has a thalweg that is in between the thalwegs seen on the Skagit River at RM 14.0 and that of the Skagit River at RM 11.2 downstream (-5 feet NGVD 29). This measure's bypass is 1500 feet wide.

Considerations for future study:

- These estimates of benefits and costs should be considered preliminary and are provided for the purpose of initial screening of management measures.
- Environmental impacts have not been evaluated.
- Costs have not been evaluated.

Measure 22 – Cockreham Island

This is a levee removal of 8,100 feet of bank on the right bank of the Skagit River just downstream of the town of Hamilton starting roughly at River Mile 39. This reconnects 1,334 acres of floodplain. This measure can also be found on page 133 of the Skagit Chinook Recovery Plan 2005.



Potential advantages of this measure include restoration of habitat, and creation of natural valley storage. Potential disadvantages include impacts to agriculture/local residents, relocation requirements, and limited storage capacity.

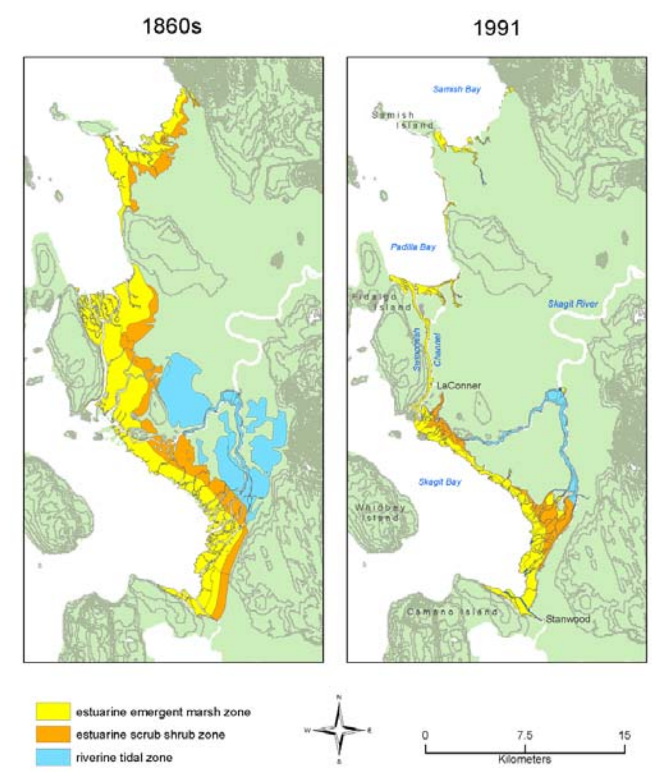
Considerations for future study:

- This measure has very limited storage capacity.
- Benefits have not been evaluated.
- Costs have not been evaluated.
- Environmental impacts have not been evaluated.
- This measure will be further evaluated as a restoration feature.

Measure 23 – Estuarine Restoration

The Skagit Chinook Recovery Plan's measures Theins Farm, Sullivans Hacienda, Wiley Slough, Milltown Island, Deepwater Slough, and Fisher Slough are all estuarine restoration projects that expand the conveyance areas near Skagit Bay. These measures will be further evaluated as restoration features.

The major potential advantage of this measure is the restoration of estuarine habitat. Potential disadvantages include impacts to agriculture/local residents, and the possibility that flood reduction benefits may be minimal.

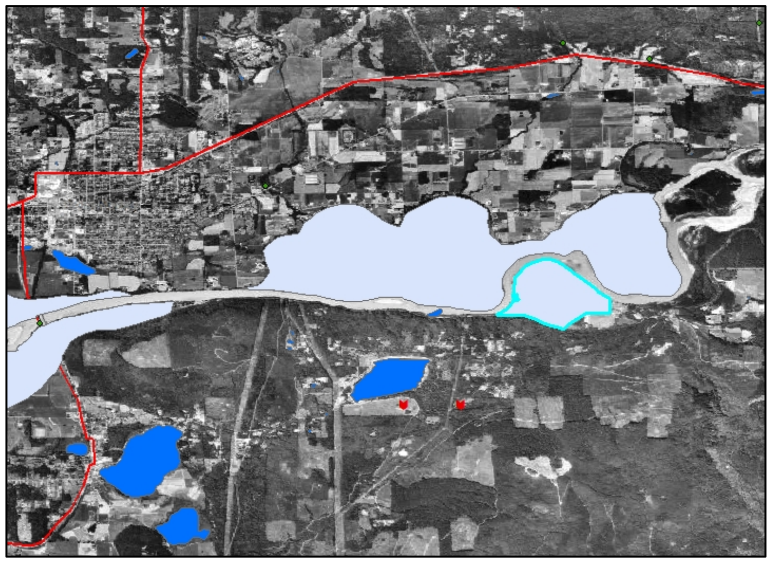


Changes to the estuarine habitat zones within the geomorphic Skagit Delta. Historic (circa. 1860s) conditions were reconstructed by Collins (2000) using archival maps and survey notes. Current habitat zones were mapped by Beamer et al. (2000b) using 1991 orthophotos (from Figure 11.1.).

Measure 24 – Riparian Restoration

These riparian restoration measures are either levee removals or levee setback. The major potential advantage of this measure is the restoration of riparian habitat. Potential disadvantages include minimal flood reduction benefits, impacts to agriculture, impacts to local residents, impacts to infrastructure, and potential increases in floodplain deposition.

Measure 24A – Gilligan Floodplain Restoration



This measure removes 560 feet of a flood control dike along the Skagit River just downstream of Gilligan Creek. The levee is on the left bank just before a bend at RM 28. This reconnects 170 acres of floodplain. This measure can also be found on page 131 of the Skagit Chinook Recovery Plan 2005. This measure will be further evaluated as a restoration feature.

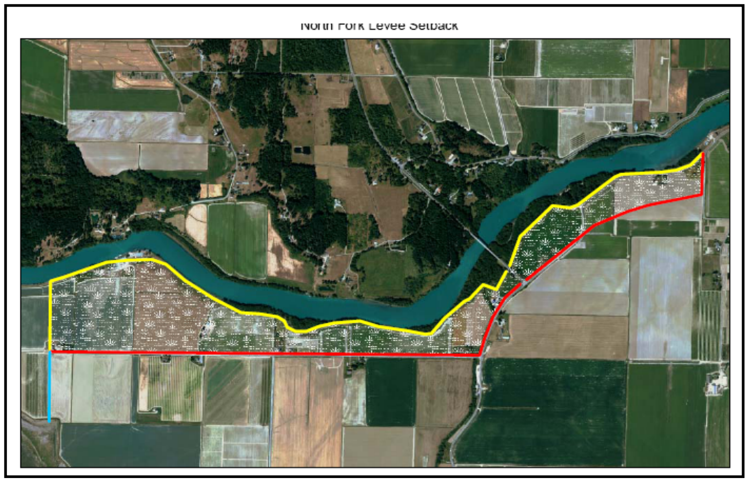
Measure 24B – River Bend

This measure removes the levee on the left bank of the Skagit River from RM 16.6 to RM 13.1 and builds a River Bend cutoff levee that would be 7600 feet long and extend from River Bend Road at RM 16.6 directly south to River Bend Road at RM 13.1. This design is detailed in PIE's Interim Evaluation of Measures Report (April 2006) on pages 185-7. A similar measure is also found on page 123-4 of the Skagit Chinook Recovery Plan 2005 with the main exception being that the floodplain is controlled by gates in the recovery plan. The gates are removed in this evaluation as this reduces the complexity of operation. It also allows water to shortcut the river from RM 16.6 to

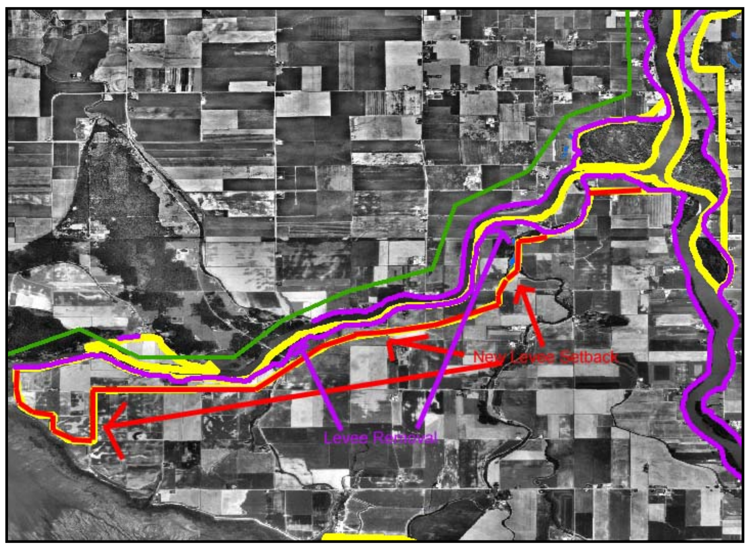
13.1 which can help to reduce flood levels. This levee location would meet Corps requirements to not encourage development in rural areas.

Measure 24C – Setback Levees North Fork Only

This setback is designed to improve the levee system's ability to move more water downstream by giving the river more area to move downstream. This setback starts at the beginning of the split into the North Fork (RM NF9.25) to where the North Fork starts widening towards the bay (RM NF 3.90) and is entirely on the left bank. This requires setting back the North Fork bridge.

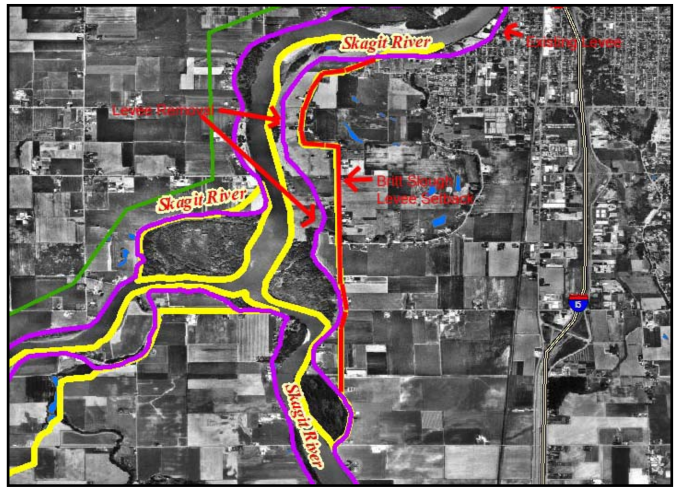


This measure is primarily an 800-1000 foot setback. The setback starts at the top of bank elevation and the levee is moved back from where it currently is. Environmental impacts have not been evaluated. However, setting back levees generally minimizes environmental impact.



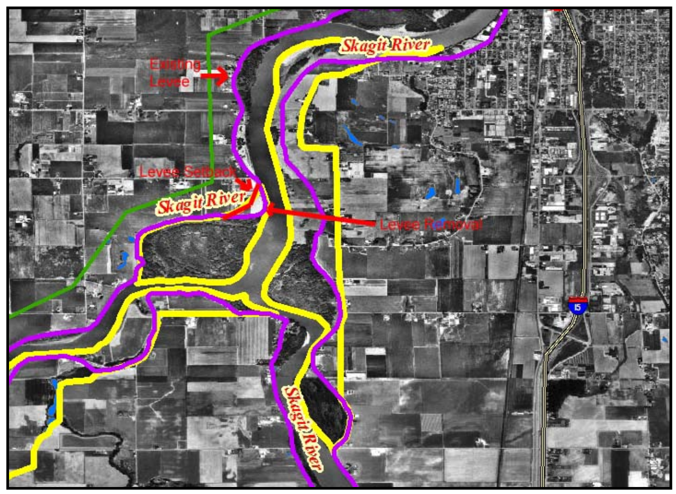
Measure 24D - Britt Slough Restoration

This measure sets back the left bank levee roughly 500 feet just downstream of Mount Vernon from RM 11.7 to RM 8.75 of the South Fork. The setback location is highlighted in red in the picture below. This measure can also be found on page 127 of the Skagit Chinook Recovery Plan 2005. This measure will be further evaluated as a restoration feature.



Measure 24E – Cottonwood Island

This measure sets back the right bank levee just upstream from where the mainstem splits into the two forks. This setback starts 1000 feet upstream of the start of Cottonwood Island and goes back 1000 feet at the island to restore the hydraulic connectivity of the slough to the river. The setback location is highlighted in red in the picture below. This measure can also be found on page 128 of the Skagit Chinook Recovery Plan 2005. This measure will be further evaluated as a restoration feature.

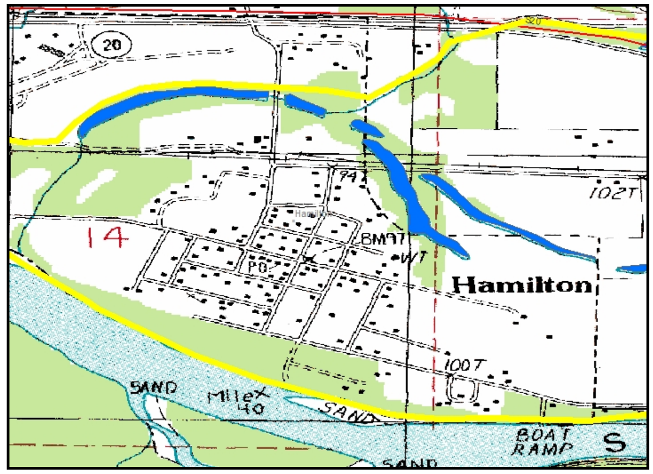


Measure 25 – Nonstructural Measures

Non-structural measures will be further evaluated in future analysis. Prerequisites to the evaluation of non-structural measures are as follows. The new hydraulic analysis must be completed, including the new levee failure analysis, followed by generation of alternatives. These prerequisites will better define the areas where non-structural measures might be practicable. Examples of non-structural measures that may be evaluated include: flood proofing, relocations, landscape features, and flood warning evacuation systems.

Potential advantages of these measures include minimal environmental impacts, and increased public safety and awareness. The major potential disadvantage is that these measures allow residual damages.

Measure 26 – Hamilton Relocation



Hamilton is being considered for nonstructural flood damage reduction and relocation. A Section 205 study completed by the Corps in the 1980's indicated that a structural solution for Hamilton is not feasible. This evaluation will take place following the non-structural measures' prerequisites identified in Section 6.5.1.49. Analysis will likely involve a benefit-cost analysis that evaluates mulitiple project alternatives such as: prioritizing the lowest lying properties, the properties with the lowest relocation cost, or the highest value properties. A flood model would be used to compare the average annual damages to a property with the cost of moving that property.

The Corps previously completed an evaluation of protecting Hamilton from flooding. No alternative was economically justified under this evaluation. The Corps, at the request of the State, will consider relocating Hamilton based on potential increased environmental benefits. The Corps will coordinate this with ongoing local efforts.

Potential advantages of this measure include the possible justification of the project on environmental grounds, the removal of structures and infrastructure from the floodway, increased public safety, and coordination with state, local, and private entities. Potential disadvantages include the possibility that environmental benefits may not economically justified, and that relocation costs are high.

Measure 27 – Debris Management

This measure is to look at different ways woody debris can be handled to avoid blockages and other situations that jeopardize the flood protection system. The existing condition assumes that in larger floods that the BNSF Bridge will collect debris in a way similar to the way it did in 1995. This condition can be seen below.

Potential advantages of this measure include the reduction of flow constriction at bridges, reduced pressure on bridges, and reduction of the risk associated with debris removal during flood events (including life safety). Potential disadvantages include loss of large woody debris that is valuable as fish habitat, and that current environmental regulation do not allow for the permanent removal of debris.

Considerations for further analysis:

- For this measure, it is assumed that the blockage at the BNSF Bridge could be prevented by some measure. Currently, we do not have a feasible plan to implement this measure and to determine what the costs are.
- No evaluation of environmental impacts has been conducted to date.
- There are potential issues in the permitting required for debris removal.

Measure 28 – Sedro-Woolley Ring Dike

This measure is to build a levee to protect Sedro-Woolley from flooding from the Skagit River.

Measure 28A – Sedro-Woolley Ring Dike – Remove All Damages

This measure looks at removing all damages from the Sedro-Woolley area. The reach that this ring dike protects is 8.

Measure 28B – Sedro-Woolley Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from the Sedro-Woolley area when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The reach that this ring dike protects is 8.

Measure 29 – Sedro-Woolley Sewage Treatment Plant Ring Dike

These measures look at improving the levee around the Sedro-Woolley Sewage Treatment Plant to reduce damages. The outline of the levee is in light green below. This schematic and costs are partially derived from page 91 of PIE's Interim Evaluation of Measures.

Potential advantages of this measure include increased protection of the sewage treatment plant, and the reduction of contamination risk. Potential disadvantages include a lack of certainty as to whether flooding is significant enough to justify improvement to the dike, and the requirement of and extensive pumping system.

Measure 29A – Sedro-Woolley Sewage Treatment Plant Ring Dike – Remove All Damages

This measure will look at removing all damages from the Sedro-Woolley Sewage Treatment Plant. The measure will be evaluated during future analysis.

Measure 29B – Sedro-Woolley Sewage Treatment Plant Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure will look at removing damages from the Sedro-Woolley Sewage Treatment Plant when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The measure will be evaluated during future analysis.

Measure 30 - Sedro-Woolley Hospital Ring Dike

These measures look at building a ring dike around the Sedro-Woolley Hospital to reduce damages. This levee would protect the area in the blue hatched lines below. Potential advantages of this measure include added protection of the hospital building, and the improved life safety of hospital patients. Potential disadvantages include the necessity of barricades at the entrances/exits to maintain egress and ingress, dangers associated with temporary loss of access to a hospital, and the required extensive pumping system.

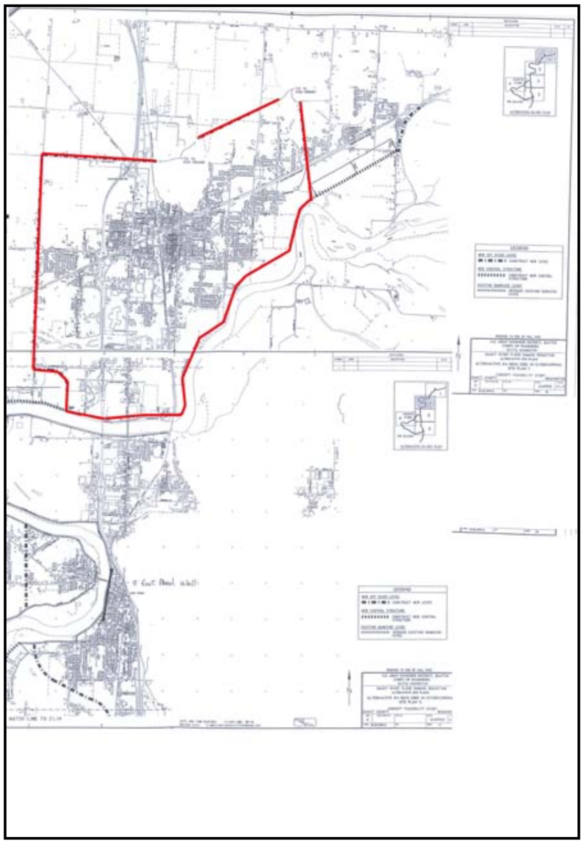
Measure 30A – Sedro-Woolley Hospital Ring Dike – Remove All Damages

This measure will look at removing all damages from Sedro-Woolley Hospital. The measure will be evaluated during future analysis. Design of the measure will need to ensure access to the hospital in a flood event. Future evaluation will need to ensure that measure does not protect undeveloped land unless absolutely necessary as defined by Executive Order 11988.

Measure 30B – Sedro-Woolley Hospital Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure will look at removing damages from Sedro-Woolley Hospital when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The measure will be evaluated during future analysis. Design of the measure will need to ensure access to the hospital in a flood event. Future evaluation will need to ensure that measure does not protect undeveloped land unless absolutely necessary as defined by Executive Order 11988. A preliminary cost analysis estimates total project costs are $7,854,003, equivalent to an annual cost of $421,935. No benefit calculation has been completed. Estimate of costs should be considered preliminary and is provided for initial screening of management measures.

Measure 31 – Burlington Ring Dike



These measures look at surrounding the city of Burlington with a levee to reduce damages. The outline of the levee is in red below. The levee follows the existing right bank levee of the Skagit River starting at RM 20.9 to RM 16.6, then heads north to McCorquadale Road and then goes west on that road, then heads North on Pulser Road to Josh Wilson Road where it heads east to high ground just past the Burlington Northern Railroad. On the other side of the high ground it heads Northeast to another area of high ground before it heads south to connect to the Skagit River levee at RM 20.9. This design path is done to limit the length and cost of the levee while also following Executive Order 11988 which requires the Federal government "to avoid direct or indirect support of floodplain development wherever there is a practicable alternative". This means that the levee can not target protecting undeveloped areas.

Measure 31A – Burlington Ring Dike – Remove All Damages

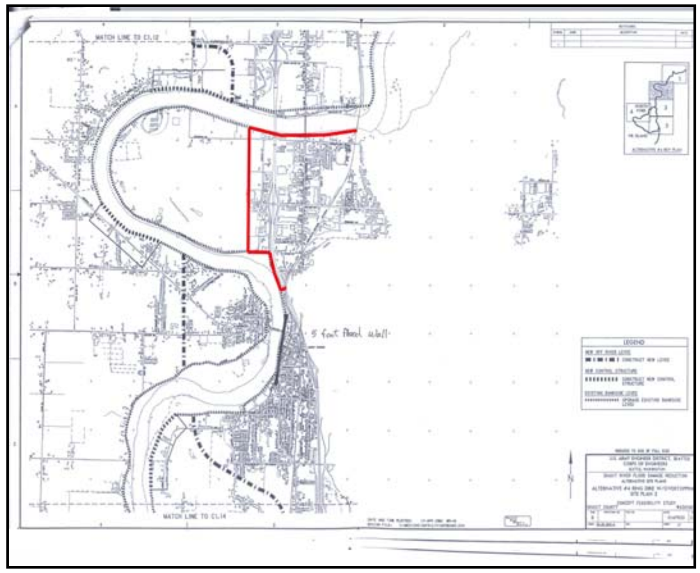
This measure looks at removing all damages from the Burlington area. The reach that this ring dike protects is 1A. This measure is a hypothetical measure used to establish a baseline for evaluation of other measures.

Measure 31B – Burlington Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from the Burlington area when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The reach that this ring dike protects is 1A.

Ring dikes isolate communities and can have catastrophic effects if they are exceeded. This measure will require an ensured escape route and an effective warning system. Additionally, the Corps will need to evaluate potential induced flooding of other areas.

Measure 32 – North Mount Vernon Ring Dike



These measures look at surrounding the northern part of the city of Mount Vernon with a levee to reduce damages. The outline of the levee is in red below. The levee follows the existing left bank levee of the Skagit River starting at RM 17.56 to RM 16.6, then heads directly south until it ties back into the levee system at RM 13.1 and then ties into the high ground of I-5 just north of East Mount Vernon. This design path is done to limit the length and cost of the levee while also following Executive Order 11988 which requires the Federal government "to avoid direct or indirect support of floodplain development wherever there is a practicable alternative". This means that the levee can not target protecting undeveloped areas. The costs for this design are derived from PIE's Interim Evaluation of Measures Report (April 2006) by combining elements 3c – DD17 Left Bank Levee – BNSF to I-5 (PIE Report page 131), and 6a – Big Bend Cutoff Levee (PIE Report page 185).

Measure 32A – North Mount Vernon Ring Dike – Remove All Damages

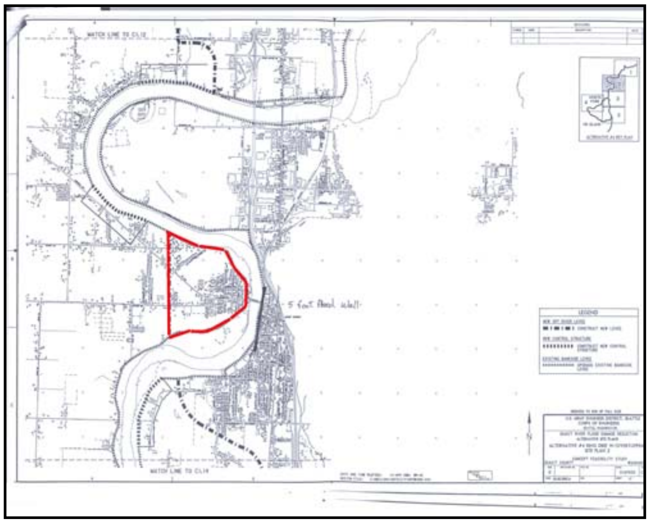
This measure looks at removing all damages from the North Mount Vernon area. This measure is a hypothetical measure used to establish a baseline for evaluation of other measures. The reach that this ring dike protects is 5A.

Measure 32B – North Mount Vernon Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from the North Mount Vernon area when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The reach that this ring dike protects is 5A.

Ring dikes isolate communities and can have catastrophic effects if they are exceeded. This measure will require an ensured escape route and an effective warning system. Additionally, the Corps will need to evaluate potential induced flooding of other areas.

Measure 33 – West Mount Vernon Ring Dike



These measures look at surrounding the western part of the city of Mount Vernon with a levee to reduce damages. The outline of the levee is in red below. The levee follows the existing right bank levee of the Skagit River starting at RM 13.83 to RM 11.7, and then completes the ring by connecting the levee at RM 13.83 and RM 11.7 roughly 4000 feet west of the Division Street Bridge. This design path is done to limit the length and cost of the levee while also following Executive Order 11988 which requires the Federal government "to avoid direct or indirect support of floodplain development wherever there is a practicable alternative". This means that the levee can not target protecting undeveloped areas.

Measure 33A – West Mount Vernon Ring Dike – Remove All Damages

This measure looks at removing all damages from the West Mount Vernon area. The reach that this ring dike protects is 2A. This measure is a hypothetical measure used to establish a baseline for evaluation of other measures.

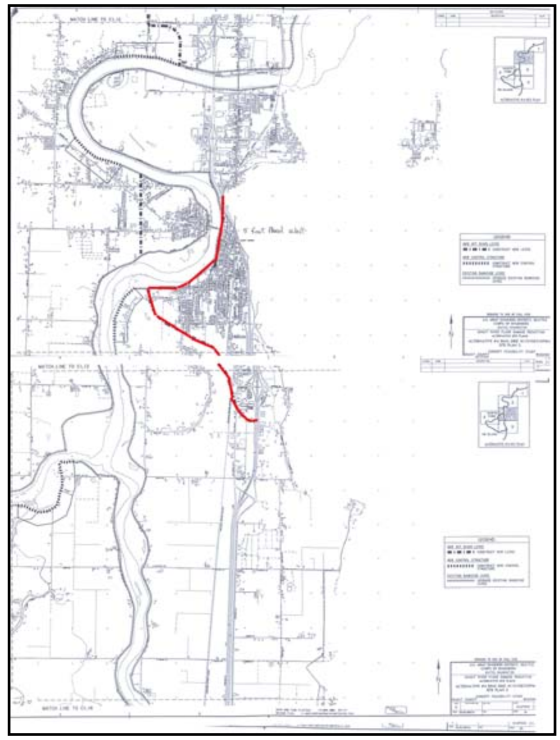
Measure 33B – West Mount Vernon Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from the West Mount Vernon area when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The reach that this ring dike protects is 2A.

Ring dikes isolate communities and can have catastrophic effects if they are exceeded. This measure will require an ensured escape route and an effective warning system. Additionally, the Corps will need to evaluate potential induced flooding of other areas.

Measure 34 – East Mount Vernon Ring Dike

These measures look at surrounding the northern part of the city of Mount Vernon with a levee to reduce damages. The outline of the levee is in red below. The levee follows the existing left bank levee of the Skagit River starting at RM 13.1, which ties into the high ground of I-5 just north of East Mount Vernon, and goes to RM 11.7. At RM 11.7, it then follows the outline of the housing developments on the south side of East Mount Vernon until it reaches high ground which is at I-5 just south of the Anderson Road exit. This design path is done to limit the length and cost of the levee while also following Executive Order 11988 which requires the Federal government "to avoid direct or indirect support of floodplain development wherever there is a practicable alternative". This means that the levee can not target protecting undeveloped areas.



Measure 34A – East Mount Vernon Ring Dike – Remove All Damages

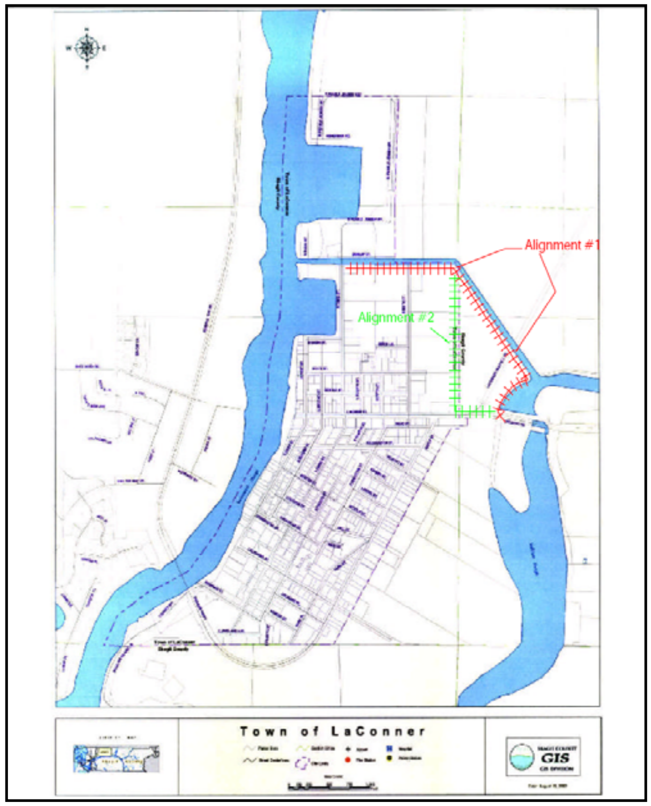
This measure looks at removing all damages from the East Mount Vernon area. The reach that this ring dike protects is 4A. This measure is a hypothetical measure used to establish a baseline for evaluation of other measures.

Measure 34B – East Mount Vernon Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from the East Mount Vernon area when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The reach that this ring dike protects is 4A.

Ring dikes isolate communities and can have catastrophic effects if they are exceeded. This measure will require an ensured escape route and an effective warning system. Additionally, the Corps will need to evaluate potential induced flooding of other areas.

Measure 35 – La Conner Ring Dike



The picture below comes from a design that was displayed in the city of La Conner's Emergency Response Plan put together by Northwest Hydraulic Consultants Inc. in February 2003. The ring dike may need to be greatly expanded as the proposed alignments tie into other levees that may not be built to appropriate standards. More study is necessary to better define the alignment and costs. The City of LaConner has requested the Corps initiate a Section 205 flood study to address this potential project.

Measure 35A – La Conner Ring Dike – Remove All Damages

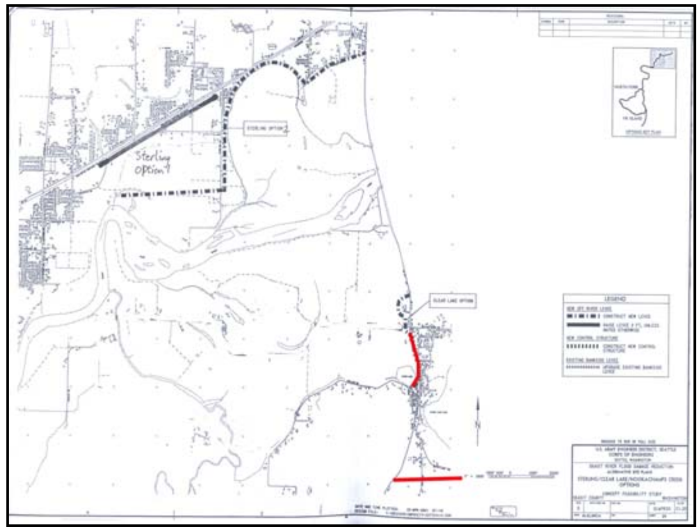
This measure looks at removing all damages from the La Conner area. The reach that this ring dike protects is 7. This measure is a hypothetical measure used to establish a baseline for evaluation of other measures.

Measure 35B – La Conner Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from the La Conner area when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The reach that this ring dike protects is 7. Ring dikes isolate communities and can have catastrophic effects if they are exceeded. This measure will require an ensured escape route and an effective warning system. Additionally, the Corps will need to evaluate potential induced flooding of other areas.

Measure 36 – Clear Lake Ring Dike

This measure addresses flood damages in the Clear Lake area. The picture below shows a preliminary design alignment for a ring dike of the Clear Lake area developed in 2001.



Measure 36A – Clear Lake Ring Dike – Remove All Damages

This measure looks at removing all damages from the Clear Lake area. The reach that this ring dike protects is 6A. This measure is a hypothetical measure used to establish a baseline for evaluation of other measures.

Measure 36B – Clear Lake Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure looks at removing damages from the Clear Lake area when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. The reach that this ring dike protects is 6A.

Ring dikes isolate communities and can have catastrophic effects if they are exceeded. This measure will require an ensured escape route and an effective warning system. Additionally, the Corps will need to evaluate potential induced flooding of other areas.

Measure 37 – Anacortes Water Treatment Plant Ring Dike

These measures will look at building a ring dike around the Anacortes Water Treatment Plant to reduce damages. The ring dike is displayed below in green. These measures will be evaluated during future studies.

Potential advantages of this measure include increased protection of the water treatment plant, and protection of water quality. The major potential disadvantage of this measure is the requirement of an extensive pumping system.

Measure 37A – Anacortes Water Treatment Plant Ring Dike – Remove All Damages

This measure will look at removing all damages from seen from the Anacortes Water Treatment Plant. This measure is a hypothetical measure used to establish a baseline for evaluation of other measures and will be evaluated during future studies. Project costs have been estimated at $1,906,327. This is equivalent to an annual cost of $102,412. No benefit calculations have been completed. Estimate of costs should be considered preliminary and are provided for initial screening of management measures.

Measure 37B – Anacortes Water Treatment Plant Ring Dike – Remove Damages Seen from a 90% Assurance of Containing the 100-year Flood Levee

This measure will look at removing damages from the Anacortes Water Treatment Plant when the stage in the river does not exceed the one that is derived to have a 90% assurance of containing the 100-year flood. **This measure will be** evaluated during future studies.

Measure 38 – 3-Bridge Corridor Modifications

This measures will consider modifying the BNRR, I-5, and Burlington Boulevard bridges and setting back levees. Other measures/alternatives will likely be considered with and without this measure to ensure that the analysis is capturing all possible benefits from reduced damages to Burlington.

Potential advantages of this measure include increased width of the channel in the 3-bridge corridor, leading to increased hydraulic capacity that can sustain larger flows.

The high expense of bridge modifications may not be justified in the alternatives analysis, but including it as a possibility will ensure that no opportunity for maximizing benefits is overlooked. In addition, running each of the identified alternatives with and without these modifications will provide information about what projects will be affordable. In reality, while bridge modifications are a measure under consideration for Federal authorization, bridge modification may need to be completed outside of the Federal authority.

This measure is currently under evaluation for hydraulic effect, costs, and potential benefits.