US Army Corps of Engineers®
Seattle District

Skagit River Flood Risk Management General Investigation

Skagit County, Washington

Draft Feasibility Report and Environmental Impact Statement

Appendix C – Economics

May 2014

ECONOMICS APPENDIX

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1. INTRODUCTION

The Economic Analysis Appendix provides information on the methodologies and details of the economic analysis conducted for the Skagit River General Investigation Flood Risk Management (FRM) Study, Skagit County, Washington (GI). Additional information regarding the GI can be found in the main Feasibility Report and Environmental Impact Statement (FR/EIS) and appendices of the GI.

1.1 Purpose of the Study

This appendix describes the economic analysis of project alternatives for providing flood risk management to urban areas in Skagit County, Washington. The purpose is to provide a comprehensive review of the methodology applied and results of the economic analysis performed in support of the GI. The report documents the existing condition within the study area and proposed alternative plans to improve flood risk management, and designate the tentative National Economic Development (NED) Plan for purposes of estimating federal interest for the Skagit River Basin. The report presents findings related to flood risk, potential flood damages and potential flood risk management benefits. This documentation is in support of the Draft Feasibility Report and Environmental Impact Statement.

1.2 Study Area

Major floods on the Skagit River are the result of winter storms moving eastward across the basin with heavy rainfall and warm snow-melting temperatures. These large, warm weather systems originate in the tropical Pacific and contain so much moisture that they are technically termed atmospheric rivers. Winter rainfall floods usually occur in November or December but may occur as early as October or as late as March. Several storms may occur in rapid succession. Successive storms pose an increased flood risk because the first storm can increase soil moisture and fill reservoir storage, causing higher discharges during the second storm.

Spring snowmelt runoff is characterized by a relatively slow, moderate rise in discharge and a long duration. Reservoirs at power-generating dams are normally refilled during the spring snowmelt, which reduces the spring peak discharges. The Skagit River and all of its major tributaries usually have low flows during August and September after the high-elevation snowpack has melted and when the base flow has partially receded.

The Skagit River drains 3,115 square miles between the crest of the Cascade Range and Puget Sound, and is shown in Figure 1-1.. Of that total, 1,214 square miles are upstream of dams that currently have dedicated reservoir storage set aside for flood regulation and 1,901 square miles are uncontrolled. The Skagit River originates in a network of narrow, precipitous mountain canyons in Canada and flows south into the United States where it continues west to Skagit Bay. After entering the United States, the Skagit River passes through Ross Dam (at river mile [RM] 105), Diablo Dam (RM 101), and Gorge Dam (RM 97). The upper watershed is steep, forested terrain with almost 90% designated as national forest or national park (Ross Lake National Recreation Area and portions of the North Cascades National Park and the Mt. Baker Snoqualmie National Forest). The primary land use in the upper Basin is recreation and open space preservation.

The three largest tributaries to the Skagit River are the Cascade, Sauk, and Baker rivers. The Cascade and Sauk rivers are the largest unregulated tributaries to the Skagit River. The Cascade River enters the Skagit River at RM 78.1, just upstream of the town of Marblemount, and has a drainage area of 185 square miles. The Sauk River is the largest tributary to the Skagit River and flows into it on the left bank at RM 67.2. The Sauk River has a drainage area of 732 miles, nearly 40% of the uncontrolled drainage area in the basin. As Wild and Scenic Rivers, the Sauk and Cascade Rivers cannot be controlled by dams or other structures. Other un-regulated discharges come from creeks that drain steep, heavily forested basins directly into the Skagit River. The Baker River is regulated as it flows through two dams Upper and Lower Baker Dams, before entering the Skagit River at Concrete (RM 56).

From Concrete, the Skagit River flows west through a narrow valley past the communities of Hamilton (RM 40) and Lyman (RM 36). Large tracts of both old-growth and secondary growth coniferous forests dominate this landscape. Primary land uses along this sparsely populated river reach are recreation and timber. The Skagit River then crosses a broad outwash plain between Sedro-Woolley (RM 24) and Skagit Bay. This coastal plain is mostly agricultural land with the main cities being Sedro-Woolley (RM 24), Burlington (RM 17), and Mount Vernon (RM13). Although Burlington's city center is upstream of Mount Vernon's, they both border the river on opposite sides for a few miles. Downstream from Mount Vernon, the river divides into two principal distributaries, the North Fork and the South Fork that discharge into Skagit Bay. In addition to the cities with their individual residential, commercial, and industrial areas, this reach of the river contains a prosperous agricultural community, and critical regional infrastructure such as I-5 and State Routes 9 and 20, the BNSF railroad, United General Hospital, and water and wastewater facilities.

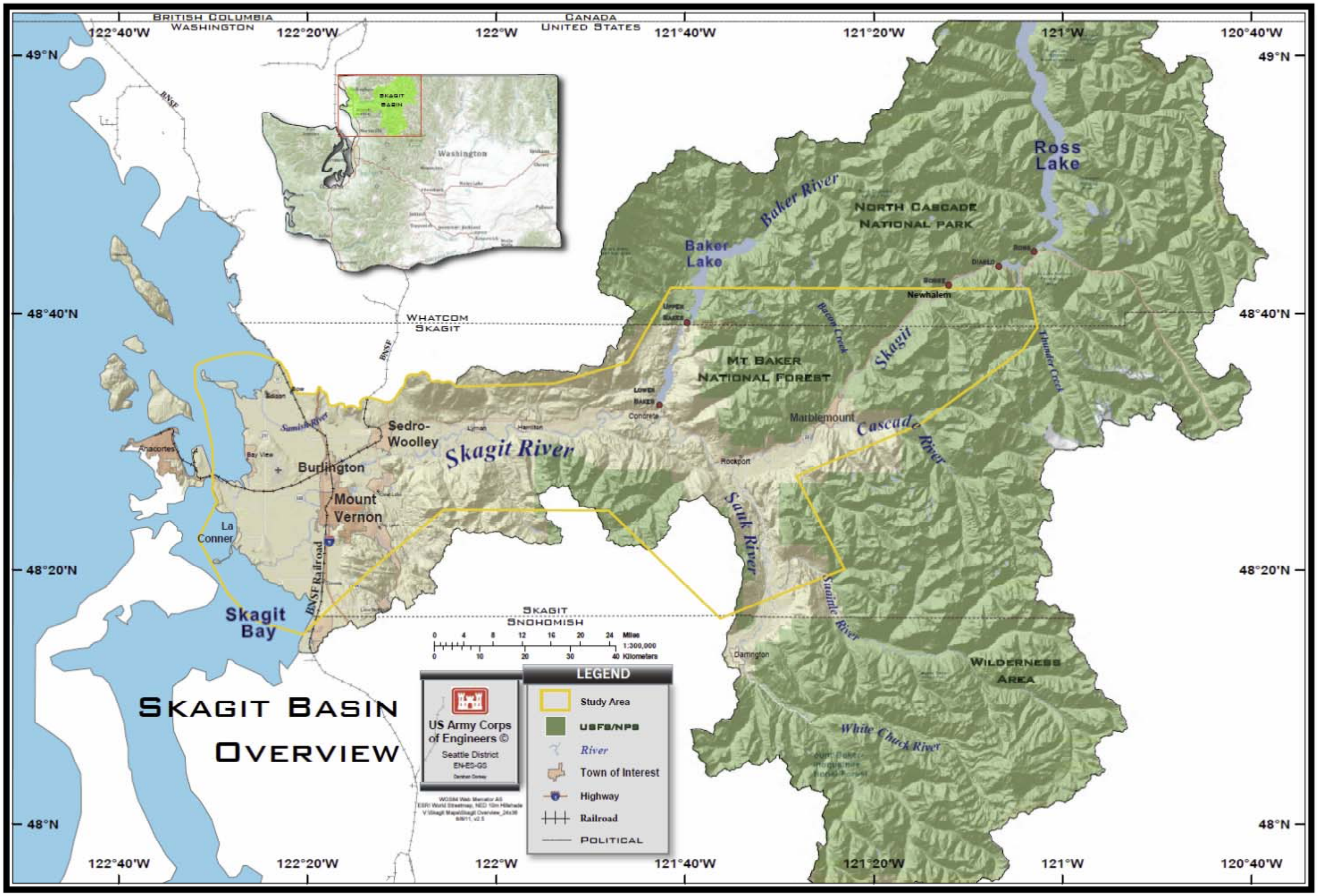

Figure 1-1. Skagit River GI Study Basin Overview Map

1.3 Economics Methodology

This economic analysis is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The Planning Guidance Notebook (ER 1105-2-100, April 2000) serves as the primary source for evaluation methods of flood risk management studies and was used as reference for this analysis. Additional guidance for risk-based analysis was obtained from EM 1110-2-1619, *Engineering and Design – Risk-Based Analysis for Flood Risk Reduction Studies (August 1996)*, and ER 1105-2-101, *Planning Risk-Based Analysis of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Risk Reduction Studies (March 1996)*. Economic evaluation was performed over a 50-year period of analysis from 2020 to 2070. All values are presented in 1 Oct 2012 price levels, and amortization calculations are based on the Fiscal Year 2014 federal discount rate of 3.5 percent as published in USACE Economic Guidance Memorandum (EGM) 14-01.

2. CHARACTERISTICS OF THE STUDY AREA

2.1 Skagit County Overview

Skagit County: Skagit County has 116,901 residents, 50% of whom live in unincorporated Skagit County; covers 1,735 square miles; and contains 8 incorporated jurisdictions and numerous communities (U.S. Census Bureau, 2011). The majority of the urban population is in the cities of Mount Vernon, Burlington, Sedro-Woolley, and Anacortes. From 2000 to 2010, the County's population increased by 13.5%.

Tribes: As noted earlier, five tribal nations have reservations or usual and accustomed (U&A) fishing rights in the Basin, and are active influential participants in management of the River with strong cultural and economic interests in the Basin. They are the Swinomish Indian Tribal Community, the Upper Skagit Indian Tribe, the Samish Indian Nation, the Sauk-Suiattle Indian Tribe, and the Lummi Nation.

City of Sedro-Woolley: The majority of the developed portion of Sedro-Woolley falls outside the floodplain. Large tracts of secondary growth coniferous forests dominate this landscape. This is an area of low density residential development.

City of Burlington: Burlington's population of 8,388 (U.S. Census 2010a) is located almost entirely in the floodplain. Since 1989 the city's assessed value of real property has increased more than tenfold. The City continues to be a hub of commercial growth (including big-box retailers) with some residential development. The city is protected by levees managed by Diking District 12.

Mount Vernon: This is a rapidly growing city with a population of approximately 32,000. Mount Vernon's core downtown area, many important public facilities, and the bulk of the city's commercial base are located in the Skagit River floodplain protected by levees in Diking Districts 17 and 3. Approximately 25% of the city area and 81% of the city's commercial zoned property is within the floodplain.

The City of Anacortes: Located on Fidalgo Island, which lies immediately west of the Skagit River Basin, Anacortes has a population of 16,933. The City of Anacortes is located outside of the Skagit River floodplain.

Critical Infrastructure in the Floodplain: Interstate 5 (I-5); BNSF Railroad; state routes (SR) 20, 9, and 536; numerous water and gas pipelines; light industry; and municipal infrastructure are located in the floodplain. Interstate commerce between Washington State and British Columbia, Canada is substantial. I-5 and BNSF railroad are critical routes through Skagit County that carry commerce between the United States and Canada. The average daily traffic count along I-5 is 71,000, of which 12% are trucks transporting commerce to (WSDOT 2012). I-5 is also the primary commute route for people who live in the Basin and work in the larger cities of Seattle and Everett to the south. State Routes 20, 9, and 536 provide the region with the transportation network to support the local and regional economy. State Route 20 is the primary transit route from the "mainland" to Fidalgo and Whidbey Islands, Naval Air Station Whidbey Island, and the ferries to/from the San Juan Islands and British Columbia, Canada. BNSF Railroad and Amtrak operate a primary railroad that runs in a north-south direction through the floodplain. BNSF currently runs 13 trains per day across the Skagit River carrying 56 million tons of freight (WSDOT 2007).

Other critical infrastructure in the basin includes United General Hospital, a wastewater treatment plant, and the LifeCare assisted living facility in Sedro-Woolley. Burlington's critical public services that lie within the floodplain include five Burlington-Edison School District schools (a sixth school is located outside the floodplain), one fire station (another fire station is located outside the floodplain), a natural gas pipeline, the sole post office in the city, the sole police station in the city, and the city hall. Mount Vernon's critical public services that lie within the floodplain include SR 536, SR 538, Skagit Transit Station, Washington Elementary School, Mount Vernon School District Transportation Center, a wastewater treatment plant, the city hall, a fire station (another two fire stations are located outside the floodplain), the city's sole police campus, wastewater and surface water pump stations, Skagit County facilities, and the Skagit County Jail. Fidalgo Island is not in the study area, but infrastructure critical to the island runs through the Skagit floodplain, including a gas pipeline and a key water supply line.

The Anacortes Water Treatment Plant is located in Mount Vernon on the left bank of the Skagit River. It serves approximately 56,000 residential, commercial, and industrial customers. The plant is the primary source of water for two oil refineries (Tesoro Northwest and Shell Puget Sound Refining Company petroleum refineries); the cities of Anacortes, La Conner, and Oak Harbor; the Whidbey Island Naval Air Station; and a significant portion of Skagit Public Utility District #1. The Tesoro Northwest and Shell Puget Sound Refining Company petroleum refineries, located in Anacortes, draw more than 60 percent of the potable water from the Anacortes Water Treatment Plant. Burlington, Mount Vernon, and Sedro-Woolley obtain their water from the Judy Reservoir System which is operated by the Skagit Public Utility District. The Judy Reservoir System is fed by tributaries draining the Cultus Mountains. The municipal wastewater treatment plants in Burlington and Mount Vernon serve more than 15,000 homes and businesses.

Four oil and gas pipelines that cross Skagit County are within the floodplain. These include: Kinder Morgan Pipeline, BP Olympic Pipeline, Williams Northwest Pipeline, and Cascade Natural Gas Pipeline. BP's Olympic Pipeline is the sole supplier of jet fuel for SeaTac airport (Olympic 2014).

<u>Agriculture</u>: The lower Skagit River Basin has some of most productive farmland in Washington State. As of the 2007 Census of Agriculture, Skagit County has 108,541 acres of land in farms (USDA 2007), a large portion of which is located in the Basin and is protected through Skagit County's Farmland Legacy Program, a county initiative that purchases agricultural easements on Skagit farmland. Agriculture in the Basin is predominantly fruit and vegetable, seed, flower production, and dairy, with some chicken production as well. Vegetable and fruit crops produced in the basin include blueberries, cauliflower, broccoli, peas, potatoes, raspberries, and strawberries. The Basin is the fifth largest dairy producer in Washington State. Organic farming is increasing in the Basin; in 2011, there were 5,627 acres in certified organic production (WSU 2011).

Seed production is a major agricultural industry in the Basin and requires coordination among the eight vegetable seed companies. Seed production is highly technical and involves long rotation intervals (years, even decades). Approximately 8% percent of the world's spinach seed, 25% percent of the world's cabbage seed, and 25% percent of the world's beet seed is produced in the Basin (WSU 2011).

Other seeds produced in the basin include arugula, broccoli, Chinese cabbage, coriander, mustard, parsley, parsnip, rutabaga, swiss chard, and turnip.

The Skagit River Basin is a major producer of tulips, daffodils, and iris bulbs, with approximately 1,100 acres planted per year for bulbs and cut flowers. The Basin contributes approximately 75% of U.S. commercial tulip production (WSU 2011). Every April, over 300,000 people attend the Skagit Valley Tulip Festival which contributes to the local economy.

2.2 Flood History

Major floods on the Skagit River are the result of winter storms moving eastward across the basin with heavy precipitation and warm snow-melting temperatures. Several storms may occur in rapid succession, raising antecedent runoff conditions and filling various river storage areas. Flood risk reduction is provided by a combination of reservoirs and levees. In the upper watershed, Ross and Upper Baker dams provide flood regulation. In the lower basin, levees line the river starting near the mouths of the North and South Forks and continuing upstream past Burlington. Generally, the most serious flooding in the study area would be due to levee failure or overtopping. Flood depths could be up to 8 feet in some places, with flood durations of 2-3 days. The flood-prone area includes the cities of Burlington and Mount Vernon, with their high population densities and critical infrastructure, such as roads, hospitals, water treatment plants, and commercial and industrial development.

The four largest documented floods on the Skagit River occurred in 1897, 1909, 1917, and 1921, before the construction of any dams in the basin. The largest floods since the completion of Ross Dam in 1953 occurred in 1990, 1995, and 2003. In 1990, two significant floods occurred in November. Both floods broke through the Fir Island levee and inundated most of the island's farmland. Both floods required extensive flood fighting in the vicinity of Mount Vernon. The 1995 flood also occurred in November, but this time the flood fight efforts were successful at preventing a levee failure at Fir Island and significant damage to downtown Mount Vernon. In 2003, there were again two floods in one month, this time in October. The Skagit River at Mount Vernon was above the zero-damage stage for 64 hours and above the major-damage stage for 47 hours. Due to reservoir regulation and sandbagging efforts, levees at Mount Vernon and Fir Island were able to withstand the flood without failing. Based on the flood peaks at Concrete, the 1990, 1995, and 2003 floods had annual chances of exceedance (ACEs) of approximately 10%, 4%, and 4%, respectively.

In this report, the risk of an individual storm or flood event occurring is expressed as the annual chance of exceedance (ACE), which is the probability that the specified discharge, or flood event, could be equaled or exceeded during any given year. A "1% ACE flood" has in the past commonly been referred to as a "100-yr flood". The occurrence of a specific ACE flood in any given year does not alter its ACE in the next year. Many documents referenced in this report, along with maps and other supporting materials, use "x-year flood" expressions, in which the number of years is sometimes known as "the return interval." To aid in understanding these differing expressions, Table 2-1 provides a cross-reference between ACE and return-interval expressions.

Table 2-1. Annual Chance of Exceedance (ACE) Conversion from Return-Interval in Years

Annual Chance of Exceedance (ACE) in %	Average Return Interval in Years
50	2
10	10
5	20
4	25
2	50
1	100
0.4	250
0.2	500

There were no levee failures in 1995 or 2003, but that was largely due to the flood fighting efforts that occurred. However, future flood fighting efforts may be overwhelmed in large flood events and are not sustainable for long term flood risk management. Throughout this report, the locations of levees, structures adjacent to the river and events such as levee failures are described referencing their position on either the right bank or the left bank of the river looking downstream.

2.3 Hydrology and Hydraulics Overview

The four largest documented floods on the Skagit River occurred before stream gages were installed on the river. Based on the peak discharges at Concrete, the largest occurred in November 1897 and had a peak discharge of 265,000 cfs. The others, all with peak discharges greater than 210,000 cfs, occurred in 1909, 1917, and 1921. Between l920 and late 1950, Ross Dam on the upper Skagit River provided only incidental flood regulation and the largest flood during this time had a peak discharge at Concrete of 154,000 cfs. Since 1953 Ross Dam has provided 120,000 acre-feet (ac-ft) of flood control storage. In 1977, Upper Baker Dam began providing 74,000 ac-ft of flood control storage. The largest flood discharges at Concrete since 1953 were a 160,000 cfs peak in 1995 and a 166,000 cfs peak in 2003. Peak discharges for selected floods, including the currently published peak discharges for the four historical floods, are listed in Appendix B (Hydraulics and Hydrology). The current natural and regulated peak flood discharges that could occur at Concrete in floods of various ACE are listed in Table 2-2. Life loss associated with historic flood events includes one death in the 1917 flood, two deaths in a 1935 flood and one death in 1995.

Table 2-2. Current natural and regulated peak flood discharges at Concrete, in cubic feet per second.

ACE	50%	20%	10%	4%	2%	1.3%	1%	0.4%	0.2%
Natural*	77,300	120,500	153,300	201,200	229,300	255,500	272,400	325,400	363,600
Regulated**	77,300	101,100	127,700	165,300	189,100	211,400	225,400	279,700	324,400

* Natural discharges are those that would occur without any regulation via dams/reservoirs.

** Regulated discharges are regulated at Ross and Upper Baker dams according to current Water Control Manuals.

The majority of the Skagit River flood risks, both economic and life safety, are in the lower basin downstream from Sedro-Woolley. Of particular concern are the cities of Burlington and Mount Vernon, with their concentrations of population and infrastructure. The conceptual diagram in Figure 2-1 illustrates the relative locations and magnitudes of potential flooding. From RM21 downstream to the mouths, most of the river is lined with levees that are located close to the river. The levee systems along the river generally have the capacity to contain a 4-5% ACE flood. Flooding in this area generally results from levee over-topping or failure. Once floods overtop or breach a levee, the levees prevent the floodwaters from return-ing to the river. If a levee fails, flood depths could be up to 8 feet in some places for a 1% ACE flood with a 2-3 day duration.

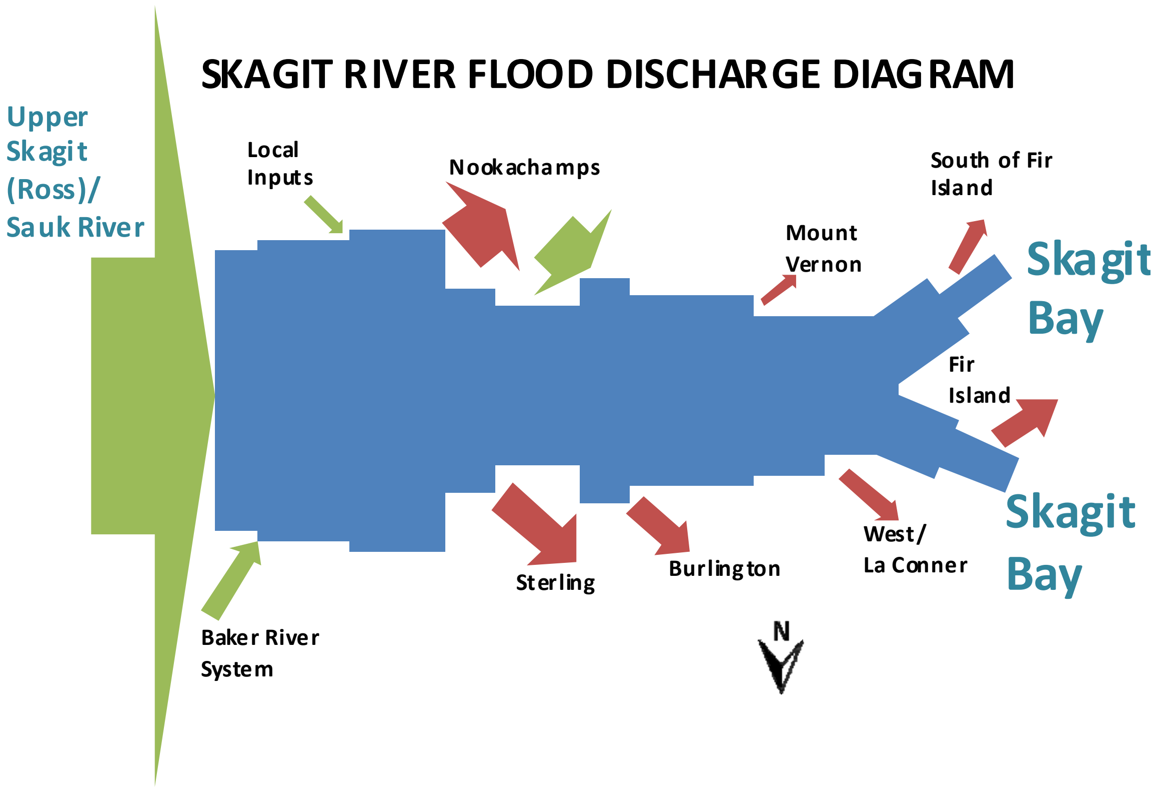

Figure 2-1. Skagit River Flood Discharge Conceptual Diagram

The floodplain depicted in Figure 2-2 is a composite of the flooding expected at the 1% ACE magnitude that could occur from individual levee failures allowing floodwaters into each of the separate floodplains. This degree of flooding is unlikely to occur during any single flood because a levee failure at one location would likely lower water surface elevations upstream and downstream, thus reducing risk of additional levee failures. This method of floodplain mapping has been chosen because it is not possible to reliably predict where a levee failure may occur during any individual flood. This floodplain, as expected in a 1% ACE flood, is the floodplain discussed throughout this report unless otherwise indicated.

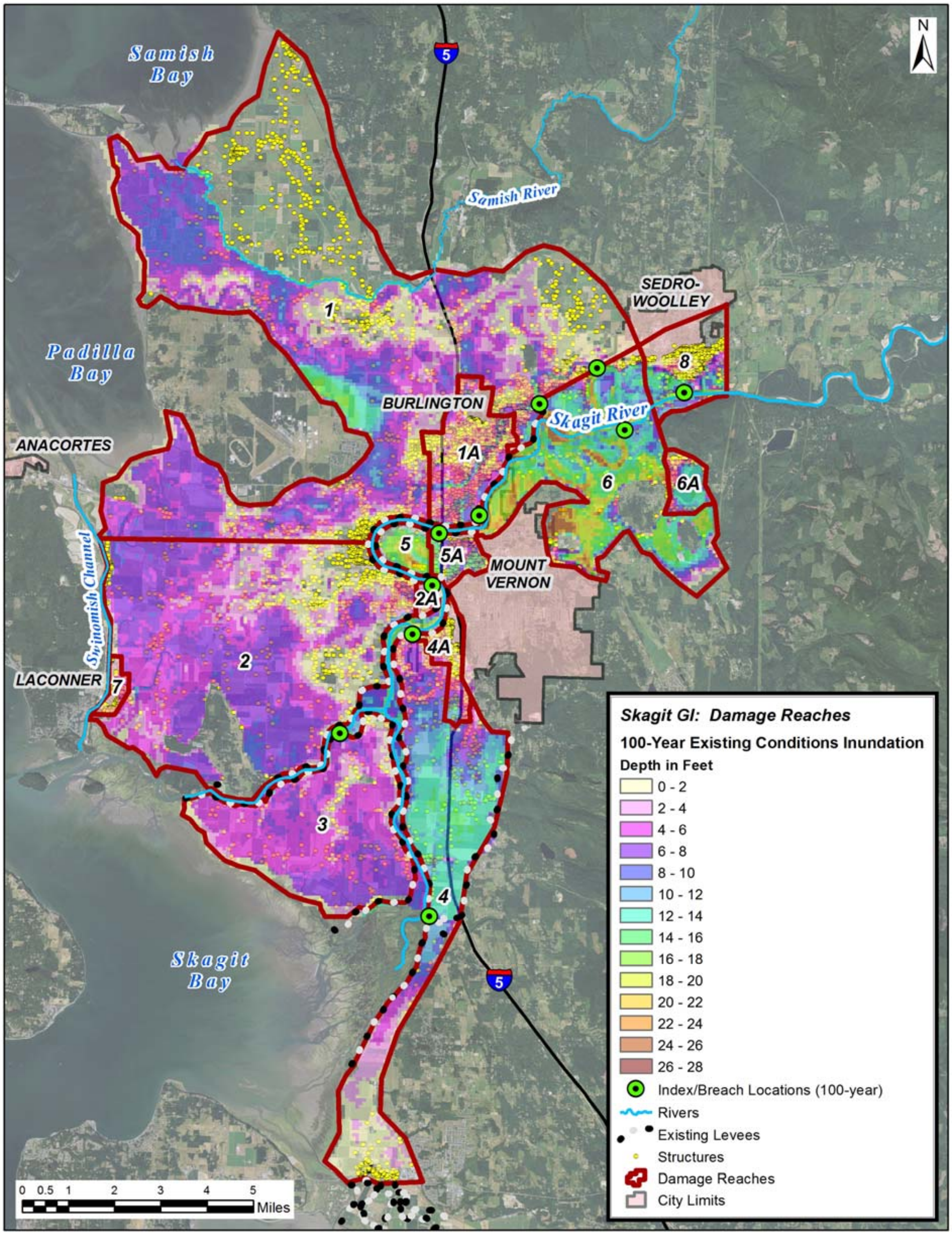

Figure 2-2. Skagit River 1% ACE floodplain with multiple levee failures

Between Sedro-Woolley and Mount Vernon, the Nookachamps Creek Basin is an un-leveed area along the left overbank of the Skagit River (RM 19-22) that floods frequently and provides substantial natural flood storage. Land use within the Nookachamps basin is largely agricultural, with the community of Clear Lake located in the southeast portion of the basin. The Nookachamps Basin also contains rich wetland and riparian habitat, and two wetland mitigation banks are under construction.

During floods greater than 4% ACE, there is the potential for the Skagit River to overflow the right bank in the Sterling area (RM 21) and in Burlington near RM 18. Floodwaters from both locations can flow west through Burlington and the western floodplain to Skagit Bay. Floodwaters from Sterling can also flow north across I-5 and the BNSF railroad and then through the rural floodplain to Padilla Bay.

At the BNSF Bridge (RM 17.5), levees and the natural topography restrict flood flows, forcing them to pass under the bridge. The hydraulics at the bridge are sensitive to debris accumulation and to floodwaters rising to the bottom of the bridge structure so that the bridge itself impedes downstream flow. The amount of debris accumulated at the BNSF Bridge affects the ability of floodwaters to pass efficiently under the bridge. With no debris accumulation, the bridge produces about a ¾ ft rise in the 1% ACE flood elevation. Debris accumulations on the order of 6,000 square feet (sq ft) can cause the water surface to rise above the bridge's structural low chord and raise the upstream water surface as much as 3 feet during a 1% ACE flood. Water surface elevations at the BNSF Bridge influence flood depths upstream in the Nookachamps area and the amount of floodwater flowing onto the floodplain that occurs at Sterling. As water surface elevations rise at Sterling, more water flows out of the river there and flood discharges downstream are reduced. The BNSF Bridge is the first of three bridges on a section of the Skagit River locally known as the Three Bridge Corridor, at RM 17.5 to 16.5. The three bridges in upstream to downstream order are: the BNSF Bridge, the Old Highway 99 Bridge, and the I-5 Bridge.

Several areas in Mount Vernon are at risk of flooding from 2-4% ACE floods, including Riverbend, West Mount Vernon, and the southern edge of the city. In the past, flood fighting has been used to reduce damages to high risk areas, such as downtown Mount Vernon. The City of Mount Vernon has plans for a new floodwall to protect the downtown area. The Mount Vernon Floodwall is partially complete, with completion planned for the near future. The floodwall will reduce the flood risks in the downtown area to less than 1% ACE. This floodwall has been included as an existing feature in this flood study.

The agricultural areas west of Mount Vernon have a 2-4% ACE flood risk. Fir Island experienced a levee failure in 1990. The town of La Conner is located north of the North Fork on Skagit Bay on the Swinomish Slough, a federally authorized navigation channel. La Conner is a local center for artists and boaters and has a strong tourist trade.

2.4 Existing Flood Risk Management in the Basin

In the Skagit River Basin, flood risk reduction is provided by a combination of reservoirs and levees. In the upper watershed, Ross Dam provides 120,000 ac-ft of flood storage and Upper Baker Dam provides up to 74,000 ac-ft of flood storage during the October through March time period. The dams provide flood regulation by storing floodwaters and releasing the stored water after the flood peak has passed downstream communities. USACE, Seattle District, manages the flood regulation operations at both dams through agreements with SCL and PSE. Together, the existing flood regulation at the two dams has the potential to reduce the 1% ACE flood peak by nearly 50,000 cfs at the flood regulation control point at Concrete. The license for the Baker River Hydroelectric Project Article 107 Flood Storage of the current Baker River Hydroelectric Project No. 2150 Federal Energy Regulatory Commission (FERC) license (FERC 2008) contains provisions that have not been implemented, for increasing the amount of time available for flood storage at Upper Baker Dam (74,000 acre feet) and/or purchasing flood storage at Lower Baker Dam (up to 29,000 acre feet) to interested parties in the lower Basin. Additional flood regulation provisions in the FERC license are not considered to be part of the existing flood regulation.

A complex system of approximately 50 miles of non-Federal levees and 39 miles of sea diking in the lower Basin is overseen by eleven different autonomous diking districts (Figure 2-3). Existing heights range from to 4-16 feet with an existing average height of 9 feet. The levee systems along the river generally have the capacity to contain a 4-5% ACE regulated flood. The Diking districts are responsible for construction, repair, and maintenance of the levee and dike systems within the boundaries of their districts. Each Diking District has the power to levy taxes for construction and maintenance of their respective levees. Each district has a different tax base and a different budget, which results in varying degrees of flood protection throughout the system.

The existing levee system is based on earthen levees built for flood control during the 1890s by the original European settlers, farmers, and homesteaders of the Skagit Valley. Each levee is composed of various materials and may be equipped with additional features such as flattened slopes, stability berms, seepage berms, driven sheet-piles, and clay seepage-cutoff trenches. The embankment material is mostly silty sand, sandy silt, and silty sand with gravel. Nearly all the levees along the river are armored with riprap for erosion protection. The extent of armoring varies with riprap placed predominantly on the revetted banks, but it may also be placed on the levee embankment or the riverward toe. See Figure 2-4 for a typical levee section.

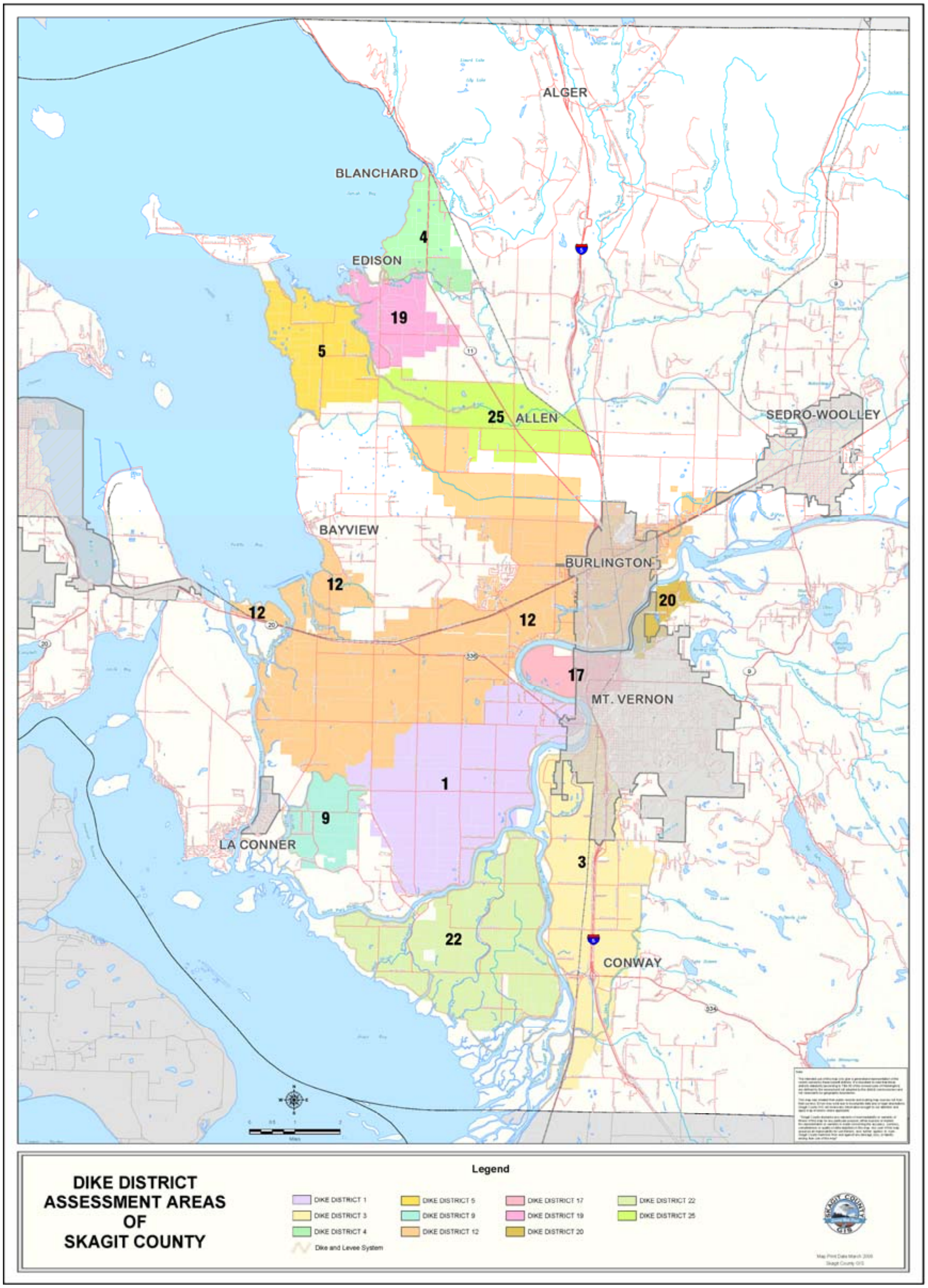

Figure 2-3. Skagit County Diking District Assessment Areas. Produced by Skagit County GIS. March 2008.

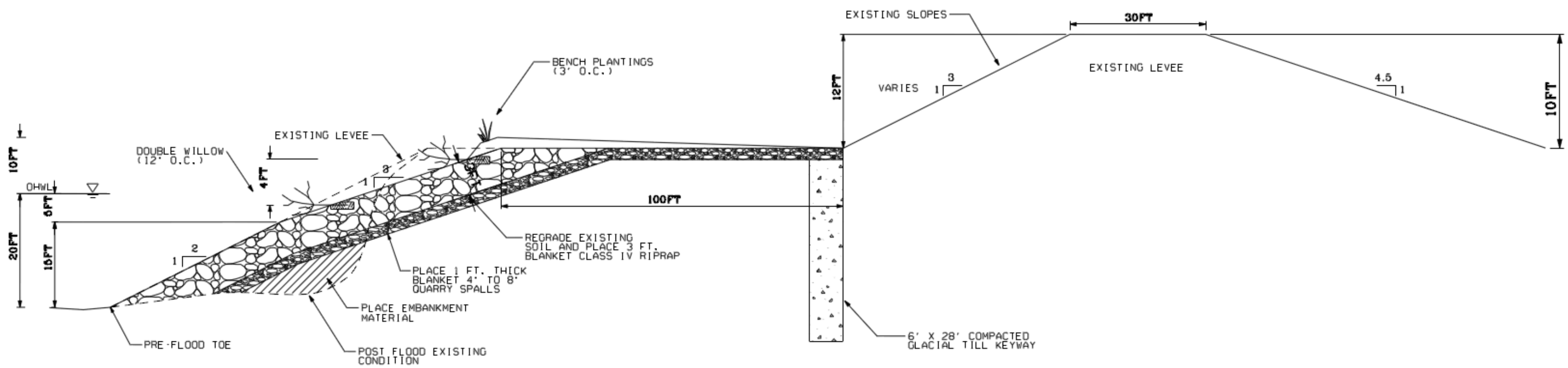

Figure 2-4. Typical levee section taken from a 2011 repair drawing.

Skagit County participates in the National Incident Management System (NIMS) when faced with hazards and incidents including floods. The County has a NIMS Standing Unified Command, consisting of the Emergency Management Director, the Sheriff, the Public Works Director, and the Public Health Director. The Flood Response is executed by the various affected fire districts, towns, cities, and diking districts. In upriver areas, response is generally needed for erosion, blocked culverts, landslides, and possible evacuations. Evacuations are led by the Sheriff's office. From Sedro-Woolley downriver, the Flood Response involves diking districts, the USACE, and cities, assisted by fire districts/departments. For larger events, the National Guard deploys to Skagit County and supports operations on the river.

Since the 1930s, USACE has been a partner with local entities during emergencies and subsequent repairs under the Public Law 84-99 Rehabilitation and Inspection Program (PL 84-99), which allows USACE 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. Every levee on the Skagit River is currently eligible in the PL 84-99 program. Personnel from the diking districts, as well as USACE and County, are very involved in annual flood fight exercises in the Basin. Flood fight efforts during past floods have helped to reduce flooding and damages in Sedro-Woolley, Mount Vernon, and Burlington. Known low points, such as along SR20 in Sterling between Sedro-Woolley and Burlington on the right bank of the River, may be sandbagged to prevent discharge of floodwaters into Burlington and the Samish Basin. The levee system in Mount Vernon on the left bank has regularly been sandbagged to protect the downtown area. However, flood fight efforts may be overwhelmed in large flood events and are not sustainable for long term flood risk management. As a result, the City of Mount Vernon has a partially completed floodwall with completion planned for the near future. The floodwall will reduce the flood risks in the downtown area to less than a 1% ACE. This floodwall has been included as a baseline condition in this flood study. It is also assumed that some minor levee reliability improvements will occur in the urban areas.

2.5 Damage Reach Characteristics

The study area was divided into 13 damage reaches for analysis based on their engineering and economic similarities, as shown in Figure 2-5. The City of Burlington makes up Reach 1A. Mount Vernon includes Reaches 2A, 4A, and 5A. La Conner is Reach 7, and part of Sedro-Woolley is included in Reach 8. Reach 6 is commonly known as the Nookachamps Creek Basin and Reach 6A is the community of Clear Lake. This study has been formulated to reduce flood risk to urban centers in Burlington and Mount Vernon. Table 2-3. shows the Skagit River damages reaches, index locations (the stream station or river mile for which various relationships which include stage, discharge, and damage are defined for a given damage reach) and top of levee (TOL) elevations for areas protected by levees at the index location for that reach.

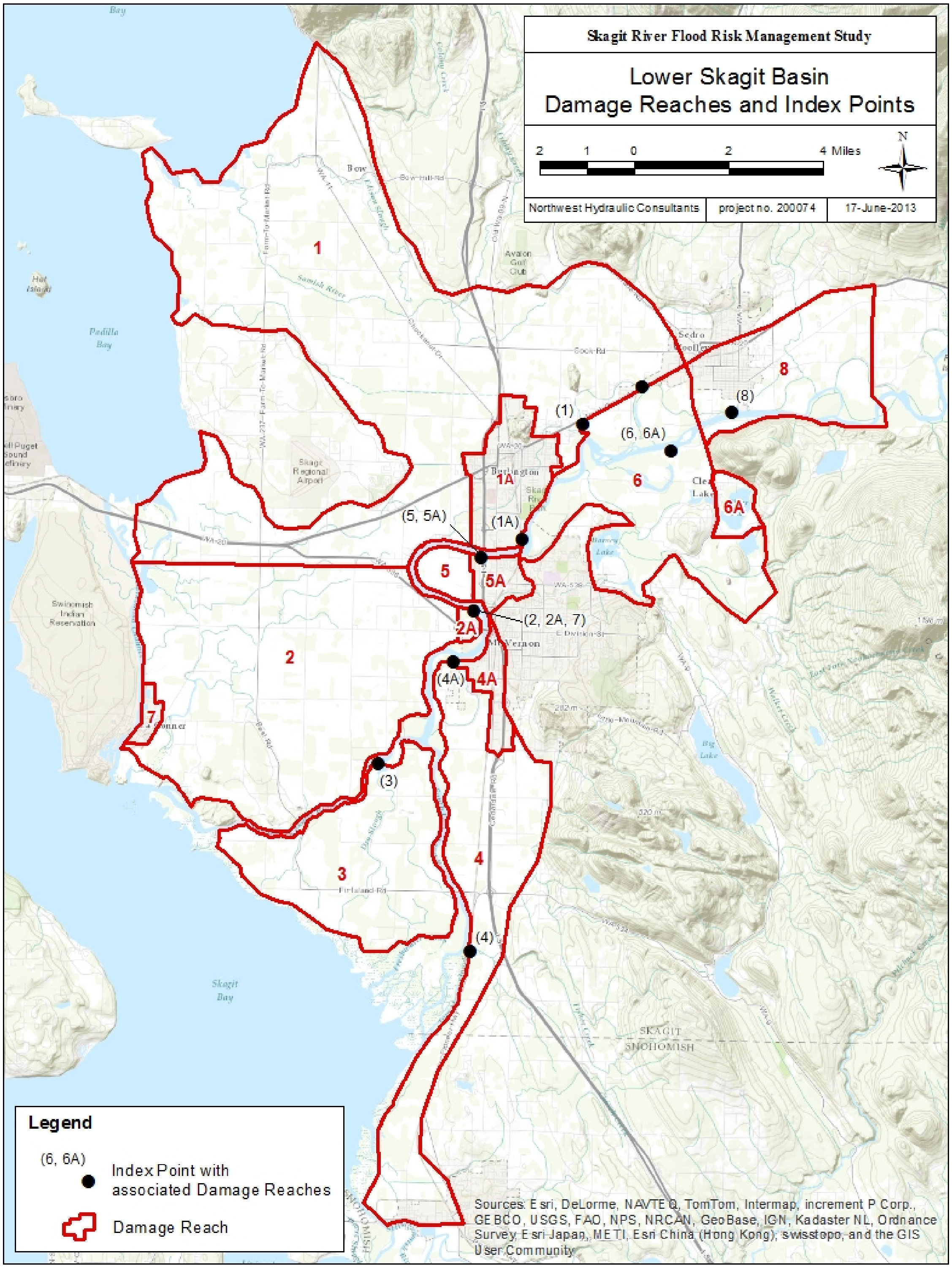

Figure 2-5. Skagit River GI Damage Reach Map

Table 2-3. Skagit River Damage Reaches

Reach Name	Description	Bank	Index Location	Beginning Station	Ending Station	Target Stage
1	Upper Right Bank Skagit Floodplain	Right	21.60	21.60	61715.00	48.66
1A	Burlington	Right	17.90	17.90	61715.00	45.46 (TOL)
2	Lower Right Bank Floodplain	Right	13.10	13.10	61715.00	37.45 (TOL)
2A	West Mount Vernon	Right	13.10	13.10	61715.00	37.45 (TOL)
3	Fir Island	Left	8.29	8.29	61715.00	27.5 (TOL)
4	Lower Left Bank Floodplain	Left	4.40	4.40	61715.00	16.74 (TOL)
4A	Mount Vernon	Left	11.70	11.70	61715.00	33.3 (TOL)
5	River Bend	Left	16.81	16.81	61715.00	45.18 (TOL)
5A	North Mount Vernon	Left	16.81	16.81	61715.00	45.18 (TOL)
6	Nookachamps	Left	22.00	22.00	61715.00	40.0
6A	Clear Lake	Left	22.00	22.00	61715.00	40.0
7	La Conner	Right	13.10	13.10	61715.00	37.45 (TOL)
8	Sedro-Woolley	Right	17.90	17.90	61715.00	47.06

2.6 Selected Socioeconomic Data

Population is one parameter of community change. As the population in an area increases or decreases, so does the demand for infrastructure. As shown in Table 2-4, population growth from 2000 to 2010 in Skagit County was less than the Washington state average at 13.5% and 14.1%, respectively. This growth is higher than national population growth, with growth of just over 9% during this same period of time. Burlington had the most significant population growth, followed by Sedro-Woolley and Mount Vernon, with population growth greater than 20% from 2000 to 2010. Approximately 34% of the residents in Skagit County reside in Burlington and Mount Vernon.

Table 2-4. Population Change 2000-2010 for Select Cities and Towns in Skagit County, Washington

Location	Population, 2000	Population, 2010	Population Change, 2000-2010
Mount Vernon, WA	26,232	31,743	21.0%
Burlington, WA	6,757	8,388	24.1%
Sedro-Woolley, WA	8,658	10,540	21.8%
La Conner, WA	761	891	17.1%
Anacortes, WA	14,557	15,778	8.4%
Skagit County	***102,979***	***116,901***	***13.5%***
Washington State	5,894,121	6,724,540	14.1%
United States	281,421,906	308,745,538	9.1%
Data Source: U.S. Census, 2000 and 2010 U.S. Census			

Table 2-5. includes more population characteristics for Skagit County. Skagit County is primarily white and has a higher 65 years and over population than the national average. The median per capita income is similar to the national average, but media housing values are almost $100,000 greater in Skagit County suggesting the county has a higher cost of living. There is a fewer proportion of people considered to be below poverty level in Skagit County compared to the national average, and the most recent unemployment rate estimate for Skagit County is 8.2%, which is lower than the 8.4% state and 8.7% national average.

Although Skagit County has a slightly higher rate of those completing high school than the national rate, there is a lower rate of people aged 25 and over who have earned a Bachelor's degree or higher compared to the national rate. Average household size in Skagit County is 2.53 people.

Table 2-5. Population Characteristics of Skagit County, Washington

	Skagit County	%	Washington State	United States
Total Population	**116,901**	**--**	**6,724,540**	**308,745,538**
White	97,448	83.4%	77.3%	72.4%
Black or African American	774	0.7%	3.6%	12.6%
American Indian or Alaska Native	2,516	2.2%	1.5%	0.9%
Asian	2,080	1.8%	7.2%	4.8%
Native Hawaiian and Other Pacific Islander	226	0.2%	0.6%	0.2%
Some other race	10,118	8.7%	5.2%	6.2%
Two or more races	3,739	3.2%	4.7%	2.9%
Hispanic or Latino	19,709	16.9%	11.2%	16.3%
Age				
Median Age	40.1	--	37.3	38.5
Under 18 years	27,737	23.7%	23.5%	24.0%
Between 18 and 64 years	70,288	60.2%	64.2%	63.0%
65 years and over	18,876	16.1%	12.3%	13.0%
Income*				
Median per capita income (dollars)	$27,447	--	$30,481	$27,915
Median household income (dollars)	$55,555	--	$58,890	$52,762
Median housing value (owner occupied)	$280,800	--	$283,200	$186,200
Persons below poverty level (all people, last 12 months)	--	12.0%	12.5%	14.3%
Unemployment rate	--	8.2%	8.4%	8.7%
Educational attainment, population 25 years and over*				
High school graduate or higher	--	87.9%	89.8%	85.4%
Bachelor's degree or higher	--	23.7%	31.4%	28.2%

Data Source: U.S. Census Bureau, 2010 U.S. Census
*Data Source: U.S. Census Bureau, 2007-2011 American Community Survey 5-year Estimates

Agriculture is an important activity in the lower basin. The study area contains over 71,000 acres of agricultural lands that are subject to flooding. The average proportion of agricultural land harvested is approximately 68.8 percent, based on the most recent 2002 U.S. Department of Agriculture Census of Agriculture and 2003 Extension Office reports. During the initial analysis, eleven crops were listed as the principal types for Skagit County (based on the 1996 report from the Washington Agricultural Statistics Service) comprising a total 45,360 harvested acres. Since that report, the harvested acreage and crop type have changed. Harvested acreage is down to 45,200 acres and both carrots and sweet corn have gone out of production. Production of green peas has been reduced by over 50 percent, while production of crops such as potatoes, cucumbers and raspberries has increased in total acreage. Approximately 50 percent of the acreage is in potatoes and hay.

Skagit County is home to diverse commercial enterprise. The largest private employers, include:

- Draper Valley Farms chicken processor, which employs approximately 500 people and has annual sales of approximately $80 million (WSU 2011);
- Shell Puget Sound Refinery (petroleum refinery) located in Anacortes, which produces 145,000 barrels per day (Shell 2014);
- Janicki Industries, which makes high precision tooling for aerospace, marine, wind energy and transportation, located in Sedro-Woolley;
- Tesoro Northwest (petroleum refinery) located in Anacortes, which processes 120,000 barrels per day (Tesoro 2013);
- Anacortes Casino owned by the Swinomish Indian Tribal Community, near the mouth of the Swinomish Slough;
- Regence BlueShield (healthcare);
- Dakota Creek Industries, a ship yard located in Anacortes;
- Trident Seafoods Corporation (seafood processing plant located in Anacortes); and
- Sierra Pacific Industries (sawmill located in Burlington).

Together, these private firms employ over 5,000 of the total county population.

Large public employers include three hospitals, five school districts, the five largest cities, and the County. Together, they employ an additional 6,000 people. Most of these private and public employers are located in the lower Skagit River Basin, although not all of these employers are located within the floodplain.

Table 2-6. displays employment by major industry sector, with the largest industry sectors in education services, health care, and social assistance; retail trade; and manufacturing. Employment status is displayed in Table 2-7.. The unemployment rate in Skagit County is estimated at 5 percent.

Table 2-6. Total and Part-Time Employment by Major Industry Sector

Employment	Skagit County	Washington State	United States
Total Employment	**51,185**	**3,135,962**	**141,832,499**
Percent Employment by Industry			
Agriculture, forestry, fishing, hunting, mining	4.4%	2.5%	1.9%
Construction	8.2%	7.0%	6.8%
Manufacturing	11.6%	10.5%	10.8%
Wholesale trade	2.8%	3.1%	2.9%
Retail trade	12.8%	11.6%	11.5%
Transportation and warehousing, utilities	4.7%	5.1%	5.1%
Information	1.5%	2.5%	2.3%
Finance, insurance, real estate, rental and leasing	5.6%	6.0%	6.9%
Professional, scientific, management, administrative and waste management services	7.8%	11.8%	10.5%
Educational services, health care and social assistance	21.1%	21.0%	22.5%
Arts, entertainment, recreation, accommodation and food services	9.5%	8.8%	9.0%
Other services, except public administration	4.6%	4.6%	4.9%
Public administration	5.4%	5.4%	4.9%
Data Source: U.S. Census Bureau, 2007-2011 American Community Survey 5-year Estimates			

Table 2-7. Employment Status

	Skagit County	%	Washington State	United States
Population 16 years and over	***92,095***	**--**	***5,269,197***	***241,302,749***
In labor force	56,513	61.4%	65.9%	64.8%
Employed	51,185	55.6%	59.5%	58.8%
Unemployed	4,600	5.0%	5.4%	5.6%
Not in labor force	35,582	38.6%	34.1%	35.2%
Data Source: U.S. Census Bureau, 2007-2011 American Community Survey 5-year Estimates				

2.7 Land Use

Skagit County's eastern boundary falls on the Cascade Mountain crest. Three-fourths of the County is mountainous with a number of peaks that rise above 8,000 feet in elevation; the County's highest peak is Mount Buckner, which stands at around 9,100 feet in elevation. The terrain in the mountainous areas of eastern Skagit County is one of extreme topography and rugged scenic beauty, with numerous glaciers and perpetual snow fields. The peaks are sharply defined and the plentiful streams of the region cascade swiftly down to the lowlands (WSWP, 1973).

One-fourth of the County's area consists of lowlands and flat valley floors. Broad alluvial flat areas cover a major part of the southwestern portion of the county where the Skagit River delta extends into Skagit Bay. The northwestern part of the county, drained largely by the Samish River, is topographically similar (WSWP, 1973).

Approximately 48% of Skagit County is in public ownership, mostly in the mountainous regions. The major public landowner is the federal government, including the Mt. Baker-Snoqualmie National Forest and the North Cascades National Park (Skagit County GIS, 2011). A land cover analysis of the County revealed that approximately 71.3% of lands are classified as forest, 6.7% as agriculture, 6.6% as water, 4.8% as ice and rock, 3.2% as developed, 3.2% as grassland, 2.8% as wetland, and 1.4% as unconsolidated shore (Skagit County GIS, 2011).

Although Skagit County has experienced significant pressures of growth, the agriculturally based economy remains strong. Skagit Valley farmers harvest the finest red potatoes in the world, produce hundreds of acres of stunning world famous tulips, provide a significant portion of cabbage and other kohlrabi crop seeds for the entire world, as well as being on the cutting edge of production for blueberries, strawberries, and raspberries. In 2009, Skagit County farmers produced approximately $300 million in products (WSU, 2010). According to the 2007 Skagit County Comprehensive Plan, there are 89,277 acres of land in Skagit County zoned as Agriculture-Natural Resource Lands, or "Ag-NRL." The County has protected more than 8,000 acres of farmland from future development through the Farmland Legacy Program. This program allows the County to purchase conservation easements, which protects open space and productive farmland in perpetuity.

The following table (Table 2-9.) from the 2007 Skagit County Comprehensive Plan summarizes all land use designations by acreage in Skagit County.

Table 2-8. Land Use in Skagit County

LAND USE DESIGNATIONS	ACREAGE
Water Bodies	[176,696]
PUBLIC OPEN SPACE OF REGIONAL/STATEWIDE IMPORTANCE (OSRSI)	
National Forest	282,812
National Park & Recreation Areas	130,848
Wilderness	83,530
State Parks & Recreation Areas	5,425
Other	16,727
Subtotal	519,342
NATURAL RESOURCE LANDS (NRL)	
Secondary Forest (SF-NRL)	38,008
Industrial Forest (IF-NRL)	319,623
Rural Resource (RRc-NRL)	26,871
Agriculture (Ag-NRL)	89,277
Subtotal	473,779
Mineral Resource Overlay (MRO)	[61,492]
RURAL LANDS	
Rural Village Residential (RV)	2,791
Rural Intermediate (RI)	8,035
Rural Reserve (RRv)	70,378
Subtotal	81,204
COMMERCIAL/INDUSTRIAL LANDS	
Rural Business (RB)	186
Rural Freeway Service (RFS)	29
Rural Village Commercial (RVC)	20
Natural Resource Industrial (NRI)	239
Small-Scale Recreation & Tourism (SRT)	16
Rural Center (RC)	19
Rural Marine Industrial (RMI)	50
Small-Scale Business (SSB)	31
Master Planned Resort	113
Subtotal	703
URBAN GROWTH AREAS (UGA)	
Incorporated UGA Areas (not including incorporated water areas)	22,675
Unincorporated UGA Areas	11.,409
Subtotal	34,084
TOTAL	**1,109,112**

*Acreage figures are based on the best information and technology available. Accuracy may vary depending on the source of the information, changes in political boundaries or hydrological features, or the methodology used to map and calculate a particular land use. Bracketed figures represent an overlay to other land uses and do not contribute to the total acreage.

2.8 Population and Employment Projections

Table 2-9. below presents population projects to 2040 using growth rates developed by the State of Washington, Office of Financial Management. The 2007 Skagit County Comprehensive Plan includes plans to accommodate growth projected to 2025 within existing urban growth areas. Several of these areas are within the floodplain and are protected by levees. Area within the urban growth boundaries is expected to accommodate project population growth to 2025.

Table 2-9. Population and Employment Projections, Skagit County

Year	Population*
2010	116,901
2020	128,249
2030	144,953
2040	162,738

*Data source: State of Washington, Office of Financial Management, 2012 Projections, County Growth Management Population Projections by Age and Sex: 2010-2040, August 2012, http://www.ofm.wa.gov/pop/gma/projections12/GMA_2012_county_pop_projections.pdf, accessed 26 Jul 2013.

3. FLOODPLAIN AREA AND INVENTORY

3.1 Structure Inventory

A structure inventory was completed in 2010 and updated in 2013 based on data gathered from Skagit County Assessor's parcel data and field survey of structures within the floodplain. Structures were determined to be within the economic study area by using Geographical Information Systems (GIS) to compare the 0.2% annual chance exceedance (ACE) event (also known as the 500-year event) floodplain boundary plus a buffer with spatially referenced parcel numbers. Information from the assessor's parcel database (such as land use, building square footage, address, building condition, type of construction, building use code) was supplemented during field visitation by verifying data and adding fields for foundation height, specific business activity (non-residential), and number of units. Where square footage was not available, the Google Earth measuring tool was used to estimate square footage. Parcels with structures were categorized by land use and grouped into the following damage categories:

- Single-family residential – includes residential parcels represented by a single unit such as detached single family homes, individually owned condominiums and townhomes
- Multi-family residential – includes residential parcels with more than one unit such as apartment complexes, duplexes and quadplex units where each parcel may have multiple structures.
- Commercial – includes retail, office buildings, restaurants, grocery stores
- Industrial – includes warehouses, light and heavy manufacturing facilities
- Public – includes both public and semi-public uses such as government buildings, fire departments, schools and churches
- Farm – includes farm buildings and primary residences

All parcels with structures were assigned to one of the listed categories. Single-family and multi-family have been grouped together as "residential" for presentation purposes. The without project damages and with project benefits are based on potential damages to residential structures and contents, non-residential (commercial, industrial, and public) structures and contents, automobiles, farms and agriculture. Structure counts for the damage reaches described in Section 2.1 are presented in Table 3-1 and are shown as yellow dots in Figure 3-1.

Table 3-1. Structure Inventory Under Existing Conditions

Reach Name – Reach Number	Commercial	Industrial	Public	Residential	Farm	Total
Upper Right Bank Skagit Floodplain - 1	66	31	19	1,905	141	2,162
Burlington – 1A	325	92	52	2,102	3	2,574
Lower Right Bank Floodplain - 2	35	15	5	818	94	967
West Mount Vernon – 2A	37	5	3	212	1	258
Fir Island – 3	1	--	4	131	42	178

Reach Name – Reach Number	Commercial	Industrial	Public	Residential	Farm	Total
Lower Left Bank Floodplain – 4	37	12	13	472	26	560
Mount Vernon – 4A	145	53	26	437	1	662
River Bend – 5	--	--	--	17	2	19
North Mount Vernon – 5A	169	11	17	103		300
Nookachamps – 6	2	3	--	242	15	262
Clear Lake – 6A	2	1	7	155	2	167
La Conner – 7	47	2	4	226	--	279
Sedro-Woolley - 8	6	1	15	1,058	1	1,081
Totals	**872**	**226**	**165**	**7,878**	**328**	**9,469**

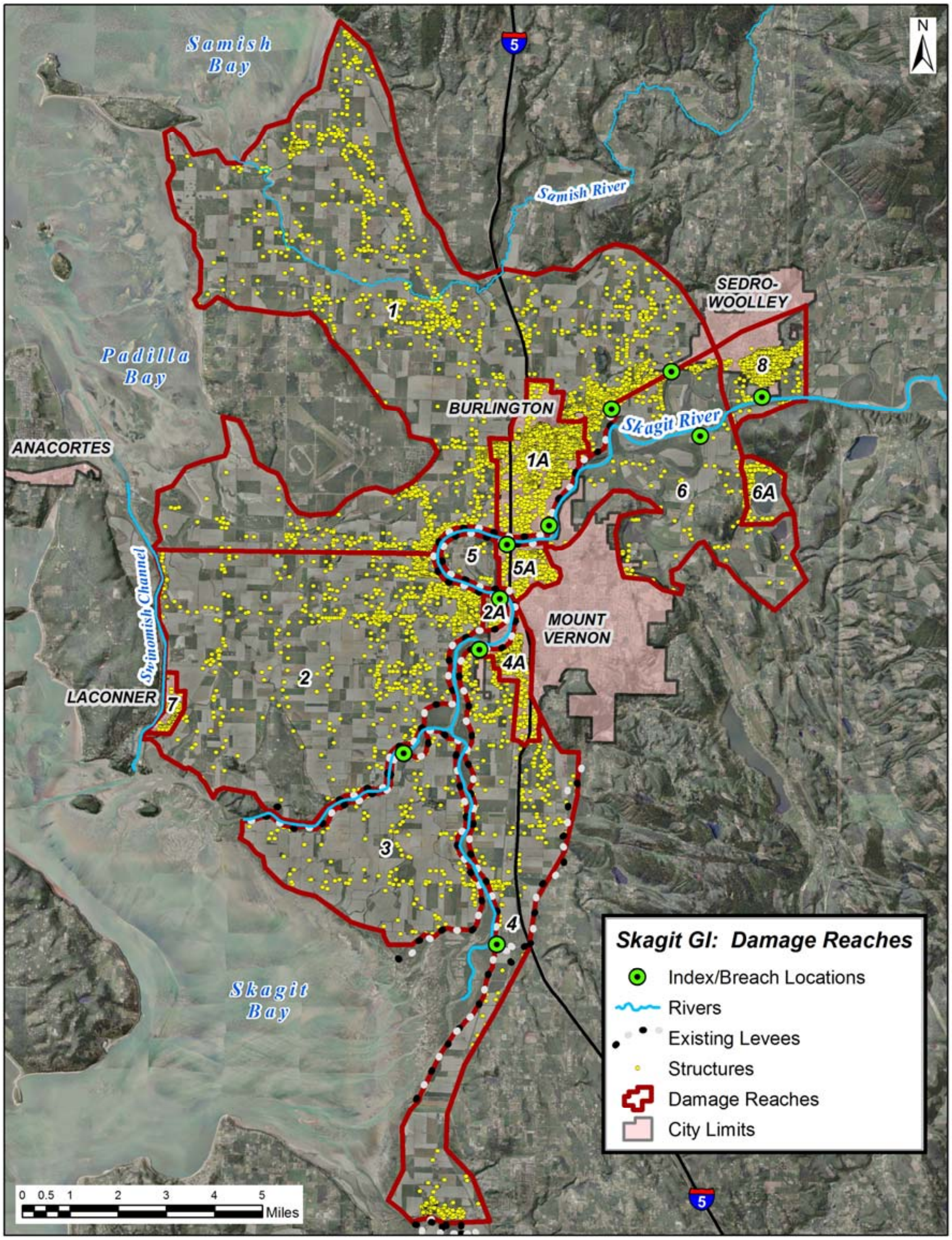

Figure 3-1. Skagit River GI Damage Reach Map

3.2 Value of Damageable Property – Structures and Contents

The value of damageable structures was estimated based on depreciated replacement values. The depreciated replacement value of a structure was determined by multiplying the structure's square footage by the cost per square foot and a remaining value ratio. Values for cost per square foot were obtained from the Marshall and Swift Valuation Service based on land use, building type, construction class, and quality. The remaining-value was based on the factors such as condition of the structure and the effective age of the structure.

The value of damageable building contents was estimated as a percentage of depreciated structure value based on associated land use. Content percentages were based on the expert elicitation findings used in the *American River Watershed Common Features Natomas Basin Post-Authorization Change Report and Interim General Reevaluation Report* (USACE, 2010).

The total value of damageable property (structures and contents) within the Skagit River 0.2% ACE (500-year) floodplain extent is estimated at $2.9 billion at the October 2012 price level. Table 3-2 displays the total value of damageable property by damage category.

Table 3-2. Value of Damageable Property (Value in $1,000s, October 2012 prices)

Reach Name – Reach Number	Structure Value ($1,000s)	Content Value ($1,000s)	Total Value ($1,000s)
Upper Right Bank Skagit Floodplain - 1	$524,092	$366,197	$890,289
Burlington – 1A	685,783	499,502	1,185,285
Lower Right Bank Floodplain - 2	150,690	133,372	284,062
West Mount Vernon – 2A	30,620	23,052	53,672
Fir Island – 3	25,886	23,568	49,454
Lower Left Bank Floodplain – 4	100,489	82,903	183,392
Mount Vernon – 4A	123,920	93,787	217,707
River Bend – 5	1,673	1,650	3,323
North Mount Vernon – 5A	172,152	113,372	285,524
Nookachamps – 6	26,818	26,595	53,413
Clear Lake – 6A	16,079	14,482	30,561
La Conner – 7	59,873	42,537	102,410
Sedro-Woolley - 8	161,355	113,020	274,375
Totals	**$2,079,427**	**$1,534,038**	**$3,613,465**

3.3 Depth-Damage Relationships

Damages to structures and contents were determined based on depth of flooding relative to the structure's first floor elevation. First floor elevations were determined based upon visual estimates during windshield surveys in the study area. Depth-damage curves were used to compute damages to structures and contents. The deeper the relative depth of flooding to the structure first floor, the greater the damage to the structure and contents.

Single-family residences in Skagit County are typical of the type of construction represented by the Corps of Engineers' generic depth-damage curves. Economic Guidance Memorandum 04-01 provided depth damage curves for residential structures and contents based on residence type (i.e. one-story single family resident without basement).

The non-residential structure depth-damage curves used for this study were based on the 1998 FEMA FIA curves and curves originally developed for the *Morganza to Gulf, Louisiana Feasibility Study (May 1997)*. These curves have been used for multiple studies in Seattle District, including the Centralia General Investigation study. For Skagit, the short duration depth damage curves were used. The non-residential content depth-damage curves used for this study were taken from the *American River Watershed Economic Reevaulation Report (ERR)* expert elicitation for short duration flooding. Interviews to develop study specific depth-damage curves are time consuming and costly to do well. They are generally done for industrial and other unique commercial and public/institutional floodplain activities for which more standardized estimating techniques are not available. Non-residential curves were not validated for this study area as the vast majority of structure and occupancy types were not unique to the Skagit floodplain. Below is a list of the structure types used for this study (Table 4-1).

Table 3-3. Structure Occupancy Types used for the Skagit River GI

Occupancy Type	Occupancy Description	Occupancy Type	Occupancy Description
	Single-Family Residential (RES)		**Commercial (COM)**
SFR1	Single-family residence, 1-story without basement	C-AUTO1	Commercial auto sales, 1-story
SFRB1	Single family residence, 1-story with basement	C-AUTO2	Commercial auto sales, 2-story
SFR2	Single-family residence, 2-story without basement	C-DEAL1	Full service auto dealership, 1-story
SFRB2	Single-family residence, 2-story with basement	C-DEAL2	Full service auto dealership, 2-story
SFRS	Single-family residence, split-level	C-FOOD1	Commercial food – retail, 1-story
SFRBS	Single-family residence, split-level with basement	C-FOOD2	Commercial food – retail, 2-story
SFRMH	Mobile home	C-FURN1	Furniture store, 1-story
	Multi-family Residential (MFR)	C-GROC1	Commercial grocery store, 1-story
MFR1	Multi-family residential, 1-story	C-HOS1	Hospital, 1-story
MFR2	Multi-family residential, 2-story	C-HOS2	Hospital, 2-story
	Industrial (IND)	C-HOTEL1	Hotel, 1-story
I-HV1	Industrial – heavy manufacturing, 1-story	C-HOTEL2	Hotel, 2-story
I-LT1	Industrial – light, 1-story	C-MED1	Commercial medical, 1-story
I-LT2	Industrial – light, 2-story	C-MED2	Commercial medical, 2-story
I-WH1	Industrial warehouse, 1-story	C-OFF1	Commercial office, 1-story
I-WH2	Industrial warehouse, 2-story	C-OFF2	Commercial office, 2-story
	Farm Building (FB)	C-REST1	Commercial restaurant, 1-story
FARM	Farm buildings including primary residence	C-REST2	Commercial restaurant, 2-story
	Public (PUB)	C-RESTFF1	Commercial fast food restaurant, 1-story
P-CH1	Public church, 1-story	C-RET1	Commercial retail, 1-story
P-CH2	Public church, 2-story	C-RET2	Commercial retail, 2-story
P-GOV1	Public government building, 1-story	C-SERV1	Commercial service – auto, 1-story
P-GOV2	Public government building, 2-story	C-SERV2	Commercial service – auto, 2-story
P-REC1	Public recreation/assembly, 1-story	C-SHOP1	Commercial shopping center, 1-story
P-REC2	Public recreation/assembly, 2-story		
P-SCH1	Public and private school, 1-story		
P-SCH2	Public and private school, 2-story		

4. OTHER DAMAGE CATEGORIES

4.1 Agricultural Losses

ER 1105-2-100, Appendix E includes specific guidance where the primary damages occur to agricultural crops. Primary damages in this evaluation focus on the crop damage. These damages are directly related and evaluated with special consideration for the expect time of seasonal flooding as well as the variability associated with crop prices and yields. The identified hydrologic and hydraulic variables, and discharge associated with exceedance frequency also apply to agricultural studies.

Based on past economic analysis of without project conditions for the Skagit River GI, flood damages to crops were estimated to not exceed 10 percent of total expected annual damages and are not expected to drive plan selection given the objective to reduce flood damages to urban areas.

Expected annual damages were estimated by utilizing FLO-2D inundation maps. USDA National Agriculture Statistical Survey (NASS) and Washington State University Cooperate Extension data were used to determine crops types in the lower Skagit River floodplain. Through farm budget analysis, the per-acre damage has been determined by considering the proportion of crops in the floodplain, and the damage by crop type by considering the seasonality of flooding. Crops types, acreage, and per acre damage are presented in the table below (Table 5-1), with an overall weighted loss of $794 per acre of flooded crops.

Table 4-1. Per Acre Crop Damage

Crop	Acres in County	Weight	Per Acre Damage	Weighted Loss
Alfalfa Hay	18,594	37%	$157	$59
Potatoes	10,353	21%	3,144	656
Corn for Silage	7,395	15%	0	0
Peas	5,203	10%	533	56
Winter Wheat	4,385	9%	268	24
Cucumbers	1,516	3%	0	0
Blueberries	1,091	2%	0	0
Raspberries	602	1%	0	0
Strawberries	481	1%	0	0
Total	**49,620**	**100%**		**$794**

Agricultural damages by flood event are shown in the Table 6-2 below. Total agricultural damages by event for each reach were linked by stage to create stage-damage curves.

Table 4-2. Total Agricultural Damages (in $1,000's)

Flood Event	Total Agricultural Damages (All Reaches)
10% ACE	$5,666,000
4% ACE	8,883,000
2% ACE	20,790,000
1.3% ACE	28,542,000
1% ACE	30,213,000
0.4% ACE	35,041,000
0.2% ACE	42,018,000

More information on crop budgets and prices are included as an attachment to this appendix.

4.2 Vehicle Damages

Losses to vehicles were determined as a function of the number of vehicles per residence, average value per vehicle, estimated percentage of vehicles removed from the floodplain prior to inundation, and depth of flooding above ground elevation. Depth-damage relationships for vehicles were taken from EGM 09-04 and modified based on weight average of vehicle type distributions (SUV, truck, sedan, sports car, etc) in Skagit County.

Average vehicle values for new and used vehicles were obtained from Kelley Blue Book based on two classes and five types of vehicles: domestic, import; and motor home, motorcycle, pickup truck, sedan, and sport utility vehicle (SUV). The representative sample of vehicles was sough with a median age according to the R.L. Polk Company's Annual Vehicle Population Report for 2008. Vehicles listed for sale within 200 miles of the study area and with similar mileage were also sought for greater consistency.

Information for determining the approximate distribution by type of vehicle and value was obtained from the Washington State Department of Licensing, where the class distribution of all vehicles registered in Skagit County was applied to the approximated number of vehicles per household. Once data was obtained, all Skagit County information was applied to the vehicle category breakdown as proposed in the EGM, and as shown in Table 4-3. The table presents the median vehicle age and valuation by vehicle class and type.

Table 4-3. Vehicle Distribution by Vehicle Type, Skagit County

Vehicle Category	Frequency	% of Total
Motor Home	2,036	2%
Motorcycle	6,248	5%
Pickup Truck	27,243	23%
Sedan	68,034	57%
Sport Utility Vehicle (SUV)	16,375	14%
Total	119,936	100%

Table 4-4. Median Vehicle Age and Value by Vehicle Type, Skagit County

Vehicle Type	2001 Median Age in Years	2008 Median Age in Years	Domestic (Value in 2010 dollars)	Import (Value in 2010 dollars)
Motor Home	12.5	Not available	Forest River Cardinal, $24,900	
Motorcycle	Not available	Not available	Harley-Davidson FXST Softail, $8,315	Yamaha XV1600AS Road Star Midnight Star, $4,720
Pickup Truck	9.4	7.6	Ford F-150, $10,995	Toyota Tundra, $7,995
Sedan	8.5	9.4	Ford Taurus, $4,999	Honda Civic, $6,995
SUV	6.1	7.5	Ford Explorer, $9,812	Nissan Xterra, $10,950

The length of potential warning time and the access to a safe evacuation route to a flood-free location was considered in estimating the number of vehicles that would likely remain in the floodplain. The percentage of vehicles that are likely to be at the residence at the time the flood waters reach the property and the availability of safe evacuation routes are a function of the amount of warning residents have. The EGM suggests that with 6-12 hours of warning, 80% of residents move a vehicle. And with greater than 12 hours of warning, 88% of residents move a vehicle. It is assumed residents would receive 12 hours of warning for inundation that is not the result of levee breaches.

Damages for vehicles begin once flood depth has reaches 0.5 feet, and this damage curve can be seen in Table 5-5. Vehicle counts were estimated using an assumption of 1.9 vehicles per residential structure based on U.S. Census data. Depreciated replacement value for vehicles was based on the weighted value of vehicles in Skagit County, or $7,041. Uncertainty in vehicle value was incorporated using a normal distribution and a standard deviation of 15 percent. Vehicles were added to residential structure imports in the "Other" valuation category and damages to residential structures, contents and vehicles is presented in the expected annual damage estimates.

Table 4-5. Depth-Damage Curve for Average Vehicle in Skagit County

Depth (ft)	0.5	1	2	3	4	5	6	7	8	9	10
% Damage	6.9%	25.9%	42.9%	58.1%	71.5%	82.9%	92.5%	97.2%	99.5%	100%	100%
Std Dev	2.6%	2.0%	1.7%	1.7%	1.9%	2.0%	2.2%	2.4%	2.4%	2.4%	2.4%

4.3 Transportation Delays

Data was collected to facilitate the estimation of losses due to road closure during flood events. Closure of a road requires that all vehicle traffic be rerouted around the closure area, increasing travel time and mileage. The value of additional travel time and the operating cost to travel additional miles is an NED damage category per ER 1105-2-100, Appendix D. The analysis of transportation delays considered two categories of delays, trucks and all other vehicles. Reroutes were based on routes determined in previous analysis. Consistent with the previous analysis, 50% of trips are assumed to be work trips, and all truck trips are valued as work trips.

The 2012 Annual Washington State Department of Transportation (WSDOT) Traffic Report was used to obtain the annual average daily traffic volume. The report estimated 67,000 Interstate 5 (I-5) at milepost 226.96, with trucks accounting for about 11% of that total. An average vehicle occupancy rate of 1.25 was used. Traffic volume for State Routes (SR) 20 and SR 9 were 17,000 vehicles (8% trucks) on SR 20, and 9,300 vehicles (11% trucks) on SR 9.

Data available from 2007-2011 American Community Survey (U.S. Census) was used to obtain the estimate for Skagit County median family income. Adjusting $64,831 to an hourly basis (2080 work hours per year) results in an hourly family income of $31.17.

Reroutes included closure of I-5 requiring use of the SR 20/Concrete bridge to cross the Skagit River, closure of I-5 requiring use of SR 20/Rockport bridge to cross the Skagit River, and closure of I-5 and SR 20 requiring an extremely long reroute through British Columbia. Table 4-6 summarizes the reroutes, and increases in mileage and time associated with the reroutes from normal traffic conditions.

Table 4-6. Alternative Route and Delays

Route	Miles	Hours	Delay Miles	Delay Hours
Normal (I-5)	15.5	0.2	0	0
SR-20 Reroute	37.8	0.9	9.3	0.3
Reroute 1 (I-5)	75.3	2.2	59.8	2.0
Reroute 2 (I-5)	90.9	2.4	75.4	2.2
Reroute 3 (I-5)	487	10.8	471.5	10.6

Vehicle operating cost damages are calculated using published 2013 AAA operating costs for an average sedan, or $0.519 per mile. A 2008 WSDOT research report cited a per mile operating cost for trucks that when updated to 2009 prices is $1.13 per mile.

Table 4-7. Transportation Delay Costs by Trip Purpose and Detour Route

	$/hr	Occupancy Factor	Time Cost	Mileage Cost	Total Cost
SR 20 Reroute					
Work	$3.01	1.25	$1.13	4.83	$5.96
Other	$1.36	1	$0.41	4.83	$5.23
Truck	$0.90	1	$0.27	10.51	$10.78
Reroute 1 (I-5)					
Work	$33.54	1.25	$12.58	31.04	$43.61
Other	$40.77	1	$12.23	31.04	$43.27
Truck	$33.54	1	$10.06	67.57	$77.64
Reroute 2 (I-5)					
Work	$36.89	1.25	$13.83	39.13	$52.97
Other	$44.85	1	$13.45	39.13	$52.59
Truck	$36.89	1	$11.07	85.20	$96.27
Reroute 3 (I-5)					
Work	$177.75	1.25	$66.66	244.71	$311.36
Other	$216.07	1	$64.82	244.71	$309.53
Truck	$177.75	1	$53.32	532.80	$586.12

The values shown in the table were used to estimate transportation delays based on the extent and duration of flooding, and the transportation reroute required.

4.4 Other Damage Categories Considered but Not Evaluated

Other damage categories considered but not evaluated include emergency costs and railroad delays. Damage quantification for these categories were not expected to drive plan selection and were not quantified for the analysis. In previous economic analyses, damage estimates for these categories were largely based on other studies or were estimated as a percentage of structure and content damages. Use of data from other study areas is not appropriate for this study, nor is the use of arbitrary percentages s a basis for damage estimates. Previous economic evaluations considered railroad delays. This was before partial completion of the Mount Vernon floodwall. With completion of the Mount Vernon floodwall, train traffic would be halted during flood events due to a stoplog closure which crosses the railroad tracks and ties into high ground. This would be the case for both the without project and with project conditions.

5. ECONOMIC MODELING AND UNCERTAINTIES

5.1 FLO-2D Grid Cells and Parcel Assignments Using GIS

GIS was used to assign centroids to each parcel within the study area and represent locations of structures. For parcels that had multiple structures, additional points were added to the file. In some cases where topography varied widely within a parcel, centroid points were moved to better represent actual locations of structures. Generally, elevations within parcels do not show much variations so most centroids were not adjusted. Ground elevations were assigned to each of the structures based on terrain data. The parcel centroids were then overload onto the grid-cells of the FLO-2D flood inundation model, resulting in the assignment of each parcel (structure) to a specific grid-cell within the hydraulic model. Due to the non-uniform nature of parcel shapes compared to the uniform nature of the FLO-2D grid cells, some grid cells contained no structures whereas others contained multiple structures. The water surface elevations of the grid cells now becomes the water surface elevation for all structures contained therein. Using the grid cell assignments along with the depths of flooding for events 4% ACE (25-year event) and less frequent, water surface profiles were developed and imported into HEC-FDA.

5.2 Economic Uncertainty Parameters

Many of the factors that determine flood damages can be represented by a range of values instead of a single number. Errors in measurement, variation in classification and judgment can lead to differences in values. In accordance with EM 1110-2-1619, uncertainties in the following parameters were considered for this study:

- Structure value
- Content-to-structure value ratio
- Depth-damage percentage by depth
- First floor elevation (foundation height)

Structure values were determined as a function of Marshall & Swift values per square foot, square footage, and estimated depreciation. A normal distribution (mean values and standard deviation) was used to represent uncertainty in structure values based by structure occupancy type.

Standard deviations for foundations heights were set to equal 0.5 feet based on the method of field survey. Standard deviations were used for all structure and content depth-damage curves, and content to structure value ratios.

These uncertainties are considered in the computation of damages using Monte Carlo simulation in the HEC-FDA model.

6. WITHOUT PROJECT DAMAGES

For the Skagit River General Investigation Feasibility Report, expected annual damages were estimated using HEC-FDA, certified version 1.2.5. Risk is a function of probability and consequence. Uncertainty about the probability and consequence of flood is inherent in flood risk management studies. HEC-FDA computes expected annual damages (EAD) by considering uncertainties in hydrology, hydraulics, geotechnical and economic parameters with Monte Carlo simulation, which include the following relationships:

- Hydrologic – The discharge-frequency function describes the probability of floods equal to or great than some discharge Q.
- Hydraulics – The stage-discharge function describes how high (stage) the flow of water in a river channel might be for a given volume of flow discharge.
- Geotechnical – The geotechnical levee failure function describes the levee failure probabilities versus stage in channel with resultant stages in the floodplain.
- Economics – The stage-damage function describes the amount of damage that might occur given certain floodplain stages.

To find the damage for any given flood frequency, the discharge for that frequency is first located in the discharge-frequency graph, then the river channel associated with that discharge value is determined in the stage-discharge graph. Once the levees fail or overtop and water enters the floodplain, the stages (water depths) in the floodplain inundates structures and cause damage (determine stage-damage function). HEC-FDA uses a sampling of the curves within the uncertainty bounds of these relationships to generate the frequency-damage curves used in EAD calculations. EAD is computed by finding the area under the frequency-damage curve by integration for a given condition (in this case, it is the without project condition). These four functions are shown in the figure below (Figure 8-1).

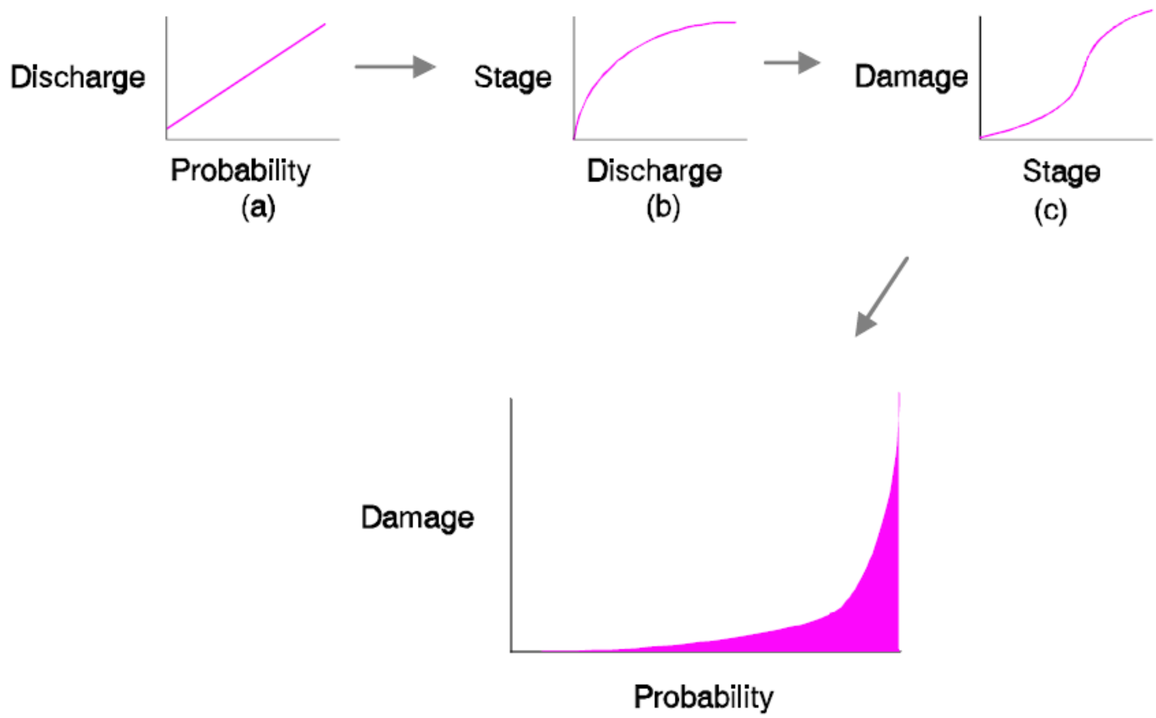

Figure 6-1. Relationships which Determine Stage-Damage and Expected Annual Damages
Source: EM 1110-2-1619

Some of the important uncertainties specific to this study include:

- Hydrologic – Uncertainty factors include hydrologic data record lengths that are often short or do not exist, precipitation-runoff computation methods that are not precisely known, and imprecise knowledge of the effectiveness of flow regulation. The period of record used for the Skagit River GI is 60 years.
- Hydraulics – Uncertainty arising from the use of simplified models to describe complex hydraulic phenomena, including the lack of detailed geometric data, misalignments of hydraulic structures, debris load, infiltration rates, embankment failures, material variability, and from errors in estimating slope and roughness factors. The standard deviation varied by damage reach based on the uncertainty factors and guidance provided in EM 1110-2-1619.
- Geotechnical – Under without project conditions, levee fragility curves were developed and input into HEC-FDA for each of the leveed reaches (all reaches except Reach 8, Sedro-Woolley).
- Economics – Uncertainty concerning land use, depth-damage relationships, structure to content value ratios, structure locations, first floor elevations, flood duration, and warning time and response (including flood fighting).

Levee fragility curves were developed for several locations that are associated with index locations within the HEC-FDA model. Levee fragility for a given levee was based on a computed 85 percent probable failure point (PFP) and 15 percent probable non-failure point (PNP), with complete failure when river stages exceed the top of levee elevation. Levee failures were modeled in HEC-RAS and FLO-2D to examine flood impacts from a given levee failure or overtopping scenario. These failures were considered in the generation of composite floodplains shown for the 4% ACE, 1% ACE and 0.2% ACE events in Figure 6-2 through Figure 6-4.

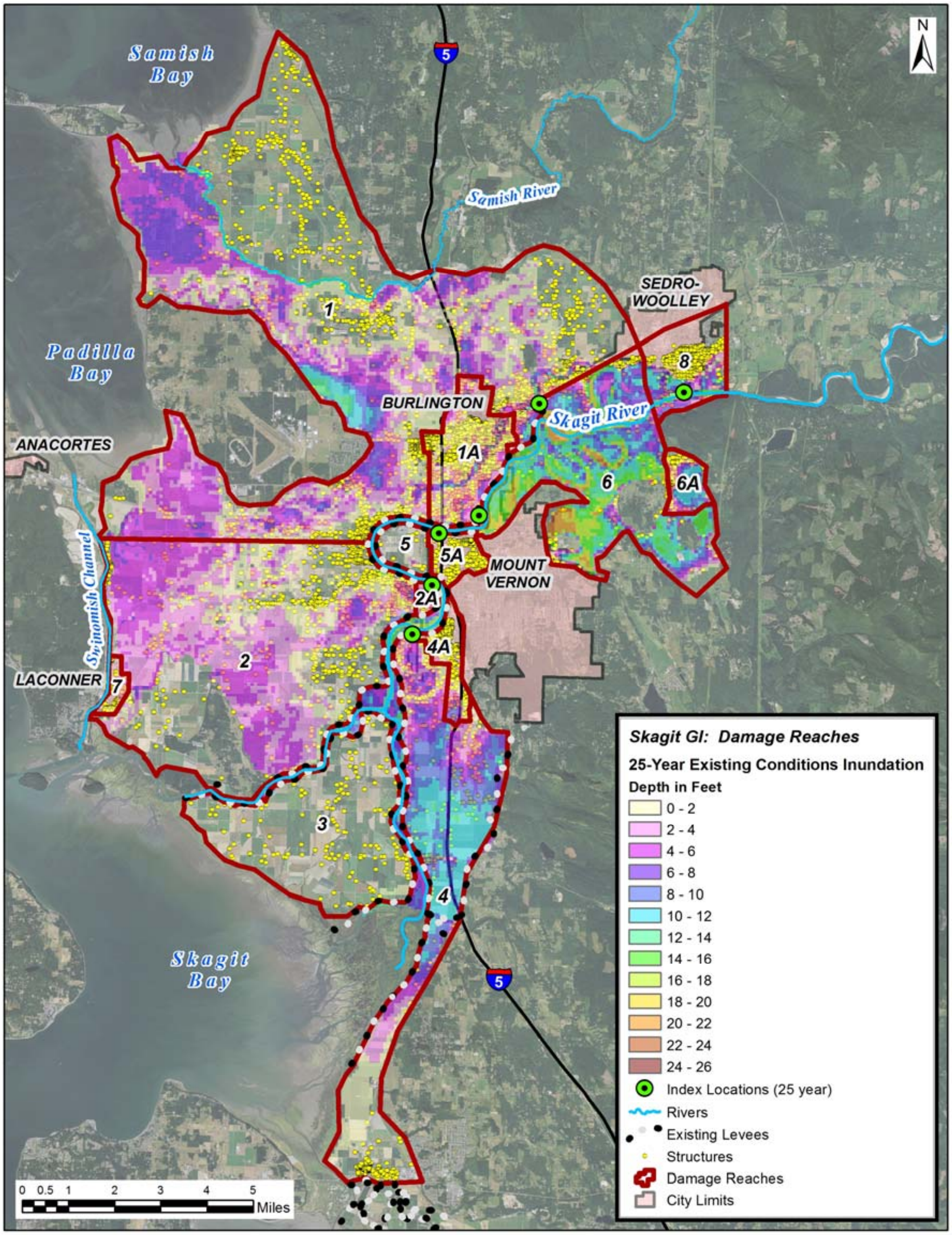

Figure 6-2. Inundation Map, 4% ACE Existing Condition

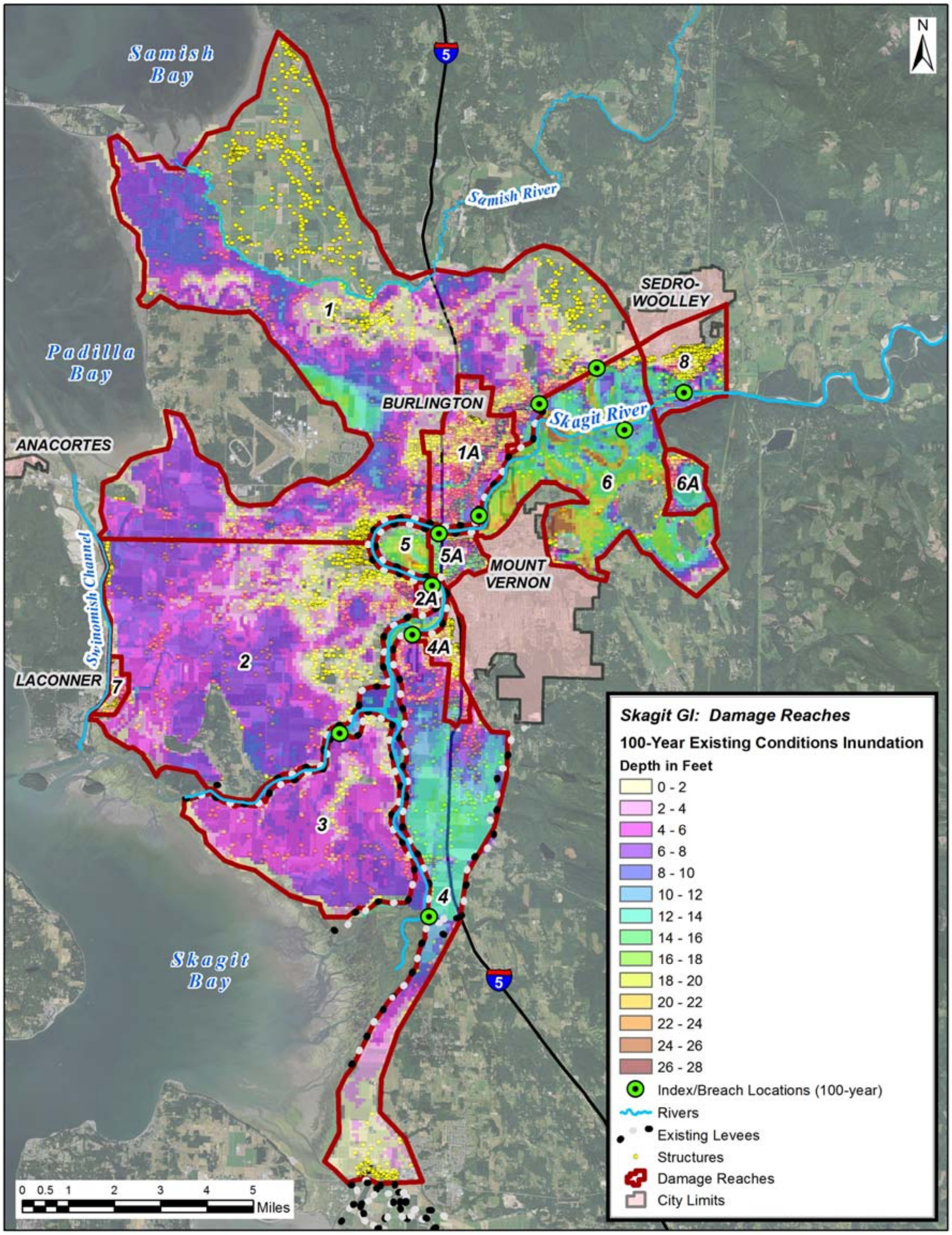

Figure 6-3. Inundation Map, 1% ACE Existing Condition

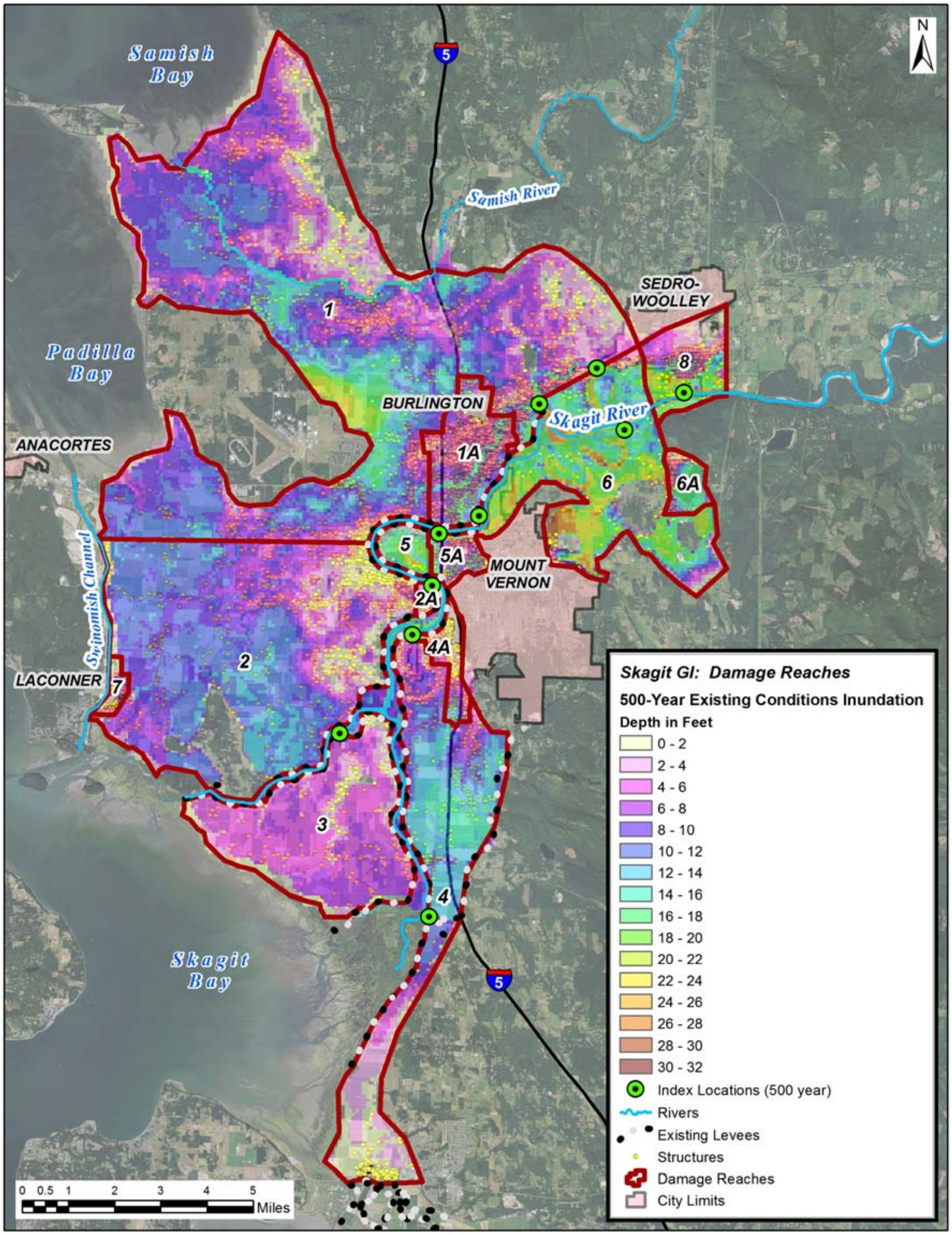

Figure 6-4. Inundation Map, 0.2% ACE Existing Condition

The existing economic, hydrologic, and hydraulic and geotechnical conditions were assumed over the period of analysis. Significant long-term flood risk would remain over the period of analysis. Assumptions related to the economic flood damage evaluation not previously mentioned include the following:

- The current land use and zoning maps for Skagit County would be followed, and all areas within urban growth boundaries would develop and be able to accommodate anticipated population growth by 2025.
- Currently developed areas subjected to flood damage would redevelop.
- Development within the floodplain would comply with FEMA regulation and take place above the 1% ACE floodplain boundary.

6.1 Single-Event Damages

Single-event damages were computed for the 50% (2-year), 10%, 4%, 2%, 1%, 0.5%, and 0.2% ACE flood events using HEC-FDA. Floodplains were based upon overtopping of banks and levees, and levee failure. Including levee elevations and fragility curves mitigates some of the high damages resulting from frequent events. The application of the levee fragility curve in HEC-FDA truncates the stage-damage function during EAD calculations for those events where a levee failure or overtopping does not occur. The 10%, 4%, 1%, and 0.2% annual chance exceedance (ACE) damages are presented in Table 6-1. and represent damages if a levee breach from the dominating breach location by reach were to occur. These damages are not adjusted for the probability of levee failure not occurring, nor do they account for uncertainties in economic parameters which estimate damages for each of the events. There is a large jump in damages from the 10% ACE and 4% ACE events. The existing flood infrastructure provides protection to around the 4-5% ACE event when flood waters spill out onto the floodplain or levees begin to overtop or breach. Nearly $1 billion in property damages to 7,000 structures is estimated for the 1% ACE event, and $1.3 billion to 9,000 structures is estimated for the 0.2% ACE event. Damage in the Burlington and Mount Vernon urban areas account for approximately 65 percent of total damage in the 1% ACE event.

Table 6-1. Skagit River Existing Condition Single-Event Damages

	10% ACE (10-year)		4% ACE (25-year)		1% ACE (100-year)		0.2% ACE (500-year)	
Reach Name – Reach Number	**Structures Flooded**	**Damage ($K)**	**Structures Flooded**	**Damage ($K)**	**Structures Flooded**	**Damage ($K)**	**Structures Flooded**	**Damage ($K)**
Upper Right Bank Skagit Floodplain - 1	34	$1,285	976	$107,021	1439	$193,857	2079	$303,565
Burlington – 1A	5	170	1942	213759	2454	374958	2559	517923
Lower Right Bank Floodplain - 2	25	2037	434	31051	624	47480	825	68717
West Mount Vernon – 2A	0	0	216	11502	241	15529	244	15841
Fir Island – 3	147	9043	147	9517	168	12111	168	12126
Lower Left Bank Floodplain – 4	9	976	300	26831	405	42799	504	48524
Mount Vernon – 4A	21	2647	274	24161	525	58092	608	66572
River Bend – 5	6	363	6	475	19	1859	19	1867
North Mount Vernon – 5A	5	715	6	1167	293	147112	293	147609
Nookachamps – 6	101	5584	132	8612	186	13440	241	18125
Clear Lake – 6A	25	1773	84	4704	153	8899	161	11403
La Conner – 7	0	0	208	13834	223	20914	257	29706
Sedro-Woolley - 8	48	4525	173	7404	492	17044	1076	92485
Totals	**426**	**$29,118**	**4898**	**$460,038**	**7222**	**$954,094**	**9034**	**$1,334,463**

6.2 Without Project Conditions – Expected Annual Damages

Hydrologic and geomorphic conditions in the upper Skagit River Basin are not expected to change significantly over the next 50 years[1]. The upper watershed is generally national park, wilderness, or forest service lands. No changes that would alter flood hydrology are expected in the park or wilderness lands. Logging on Forest Service land could increase or decrease depending on Federal policy, but either course is unlikely to have a significant impact on annual flood hydrology.

Ross and Upper Baker dams are committed to continuing to provide the current levels of flood regulation storage. The recent Baker Dam FERC relicense does provide an option for the purchase of additional flood regulation storage. Purchase of this additional storage by local governments would have the poten-

[1] Climate change may cause unprecedented alterations to the hydrology and hydraulics in the Skagit Basin, but the effects are uncertain, and were not included in the future without project condition. Sea level change (SLC) was evaluated. Both climate change and sea level change are discussed in detail in Section **Error! Reference source not found.** of the main report.

tial to reduce future peak flood discharges at Concrete by up to 17,000 cfs, reducing the flood risk to downstream communities. These provisions have not been implemented; therefore, they are not considered to be part of the future without-project condition, and future without-project flood discharges are expected to be the same as in the existing condition.

Flood risks in the lower Skagit River, downstream of Sedro-Woolley, will change when planned improvements to levees in Mount Vernon and Burlington are completed. The City of Mount Vernon has plans for a new floodwall to protect the downtown area. The Mount Vernon Floodwall is partially complete, with completion planned for the near future. The floodwall will reduce the flood risks in the downtown area to less than a 1% ACE. This floodwall has been included as an existing and future feature in this flood study. Diking District 12 has proposed raising the right bank levee upstream of Burlington, between RMs 18 and 21. Those improvements involve raising the top of levee by up to 4 feet and increasing the width of the levee. If completed, the Burlington levee improvements would be expected to reduce the risk of floodwaters spilling over the levee and into Burlington. This proposed levee raise is consistent with the levee improvements proposed in the recommended TSP. Burlington would still face flood risks from floodwaters overflowing near Sterling and possible levee breaching. Overtopping reductions that would result from the Burlington levee raise might slightly increase flood risks not only upstream but also downstream of as more floodwater would pass downstream into the urban areas.

In general, except for improvements to the Burlington levee and Mount Vernon floodwall, existing levees would continue to be maintained to their current conditions and alignments in the future without-project condition. Levee strengthening and reliability improvements, such as adding seepage berms, would continue. Local communities would continue to flood fight at known weak or low points in the levee system during flood events. USACE would continue to assist during emergencies and repairs of levees, for each levee system that remained active in the PL 84-99 program. Debris removal during floods would continue at the BNSF Bridge.

By 2060, the County's population is expected to reach almost 218,000, an increase of 86% from 2010, or 101,100 new residents (Skagit County 2011).To plan for this growth, the County has developed a 50-year plan titled Envision Skagit 2060, to ensure the protection of the watershed and promote the economic growth of the region. The Envision 2060 planning effort ended in December 2012. Implementation of recommendations are pending funding.

Bulk goods traffic on the BNSF line is expected to increase if the proposed Gateway Pacific Terminal in Whatcom County is constructed. If constructed, the train traffic through Skagit County could increase with the transport of coal and other bulk commodities exports (Gateway 2014).

The existing economic development was assumed into the future over the 50-year period of analysis ending 2070. Significant long-term flood risk would remain over the period of analysis. Assumptions related to the economic flood damage evaluation not previously mentioned include the following:

- The current land use and zoning maps for Skagit County would be followed, and all areas within existing Urban Growth Areas (UGAs) would develop to accommodate anticipated population growth by 2030. Some of these areas are located within the floodplain at Burlington and Mount Vernon. Other UGAs are located outside of the floodplain in Mount Vernon and Anacortes.

- Currently developed areas subjected to flood damage in the lower Skagit Basin would redevelop.
- New development within the floodplain is expected to comply with land use regulation pursuant to the Federal Disaster Protection Act of 1973 (Public Law 93-234) and Skagit County Code Section 14.34, and be flood proofed with the lowest floor elevated above the 1% ACE flood level.
- Currently the distribution of population growth is 80 percent to urban areas and 20 percent to rural areas. Under the Envision 2060 plan, the County will attempt to concentrate population and development within urban areas, with a population distribution goal to direct 90 percent of new population to urban areas (mostly cities and towns), and limit new rural development to 10 percent.
- Under the Envision 2060 plan, the County will attempt to prohibit UGAs from expanding into environmentally sensitive areas, including the floodplain, agricultural lands, and sensitive stream basins (including the East Fork Nookachamps).

A Monte-Carlo analysis of flood damages was conducted using the HEC-FDA model (Flood Damage Analysis), which considers uncertainties related to hydraulics, hydrology, levee performance, and economics. Expected annual damages (EAD) for the lower floodplain, which considers a full range of flood events that could occur, are estimated to be nearly $40 million as shown in Table 7-2. These include damages to property, crops (agricultural damage), and traffic delays due to inundation of I-5 and SR 9 and SR 20 in the floodplain. The greatest damage would be to residences, followed by commercial and industrial structures. Damages in the Burlington and Mount Vernon urban reaches account for approximately 46% percent of total EAD for the study area.

Population at risk of flooding was computed using inundations maps and Census data in GIS. The population at risk from the 1% ACE flood is approximately 37,000. The analysis was done by intersecting the 2010 US Census Blocks with each respective inundation layer and then summed. There was no partial calculation performed on blocks that were not entirely inundated (if any portion of the block was inundated then the entire population for that block was included).

Table 6-2. Without Project Condition Expected Annual Damages (EAD) (in $1,000s)

Reach Name – Reach Number	Commer-cial	Industrial	Public	Residen-tial	Farm Buildings	Traffic Delays	Agricul-tural Damages	Total EAD
Upper Right Bank Skagit Floodplain - 1	$576	$3,802	$96	2,772	$425	$770	$1,474	$9,915
Burlington – 1A	7,007	3,512	848	3,358	13	0	0	14,738
Lower Right Bank Floodplain - 2	183	358	69	947	285	0	2587	4,429
West Mount Vernon – 2A	243	22	80	150	2	0	0	497
Fir Island – 3	4	0	7	397	270	0	49	727
Lower Left Bank Floodplain – 4	185	304	227	1,173	241	0	217	2,347
Mount Vernon – 4A	570	577	243	370	0	0	0	1,760
River Bend – 5	0	0	0	30	3	0	1	34
North Mount Vernon – 5A	1,167	49	144	123	0	0	0	1,483
Nookachamps – 6	6	14	0	878	227	0	878	2,003
Clear Lake – 6A	8	8	38	492	11	0	0	557
La Conner – 7	157	2	253	381	0	0	79	872
Sedro-Woolley - 8	3	250	4	262	21	0	0	540
Total	$10,108	$8,899	$2,007	$11,332	$1,497	$770	$5,285	$39,898

6.3 Without Project Conditions – Project Performance

In addition to damage 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 assurance by event.

- Annual exceedance probability measures the chance of having a damaging flood in any given year. The expected annual exceedance probability is the probability of having a flood of a given stage or greater in any given year. According to Engineering Manual (EM) 1110-2-1619, the stage probability function can be used to determine this value. This EM states that analysts should “refer first to the rating function to determine the discharge corresponding to the top-of-levee stage. Given this discharge, the probability of exceedance would be found then by referring to the discharge-probability function: This probability is the desired annual exceedance probability”.

- Long-term risk provides the probability of having one or more damaging floods over a period of time (10, 30 and 50 years are presented). Once the expected annual exceedance probability (P) is known, the following equation is used to determine long-term risk for a specified period of time (n):

  $\textit{Long-term Risk} = 1 - [1 - P]^n$

  The long-term risk of having one or more floods in a 30 year period, for example, would be equal to $1 - [1 - P]^{30}$.

- Assurance is the probability that a target stage will not be exceeded during the occurrence of a specified flood. The probability that a specific event will not exceed the top of protection (top of levee or river bank), or given that a specific event occurs, what is the probability that event will be contained by a given level of protection. This value is called the conditional annual non-exceedance probability (CNP).

The worst project performance statistics may not necessarily be associated with the breach location producing the most economic damages because areas within the floodplain can flood from multiple overtopping and breach locations. Project performance for each damage reach under without project conditions is displayed in Table 6-3 below.

Table 6-3. Without Project Conditions Project Performance

Project Performance

File Help

Skagit River GI Project Performance
by Damage Reaches for the Without
(Without project condition) plan for Analysis Year 2013
(Stages in ft.)
Plan was calculated with Uncertainty

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

					Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
St Na	St De	Damage Reach Name	Da Re De	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Sk	S	4	Lo	levee	0.1328	0.2026	0.8961	0.9965	1.0000	0.3693	0.0778	0.0205	0.0143	0.0133	0.0131
Sk	N	3	Fir	levee	0.0597	0.0629	0.4776	0.8028	0.9611	0.7469	0.4231	0.2551	0.1957	0.1750	0.1619
Sk		1	Da	levee	0.0376	0.0451	0.3694	0.6843	0.9003	0.8957	0.5893	0.2914	0.1437	0.0803	0.0537
Sk		2	Lo	levee	0.0402	0.0444	0.3650	0.6787	0.8968	0.8967	0.5471	0.3051	0.2214	0.1937	0.1819
Sk		2A	W	levee	0.0401	0.0443	0.3641	0.6776	0.8961	0.8974	0.5480	0.3054	0.2224	0.1947	0.1830
Sk		4A	Mt	levee	0.0368	0.0400	0.3353	0.6397	0.8702	0.9330	0.5995	0.3047	0.2102	0.1839	0.1748
Sk		5	Ri	levee	0.0362	0.0429	0.3552	0.6661	0.8885	0.8654	0.5569	0.4147	0.3539	0.3255	0.3107
Sk		5A	Nc	levee	0.0362	0.0429	0.3549	0.6657	0.8883	0.8670	0.5572	0.4145	0.3526	0.3239	0.3089
Sk		6	Nc	levee	0.4660	0.6102	0.9999	1.0000	1.0000	0.0311	0.0016	0.0002	0.0000	0.0000	0.0000
Sk		6A	Cle	levee	0.4660	0.6103	0.9999	1.0000	1.0000	0.0311	0.0016	0.0002	0.0000	0.0000	0.0000
Sk		7	La	levee	0.0402	0.0443	0.3642	0.6776	0.8961	0.8974	0.5480	0.3054	0.2223	0.1948	0.1830
Sk		8	Se	47.06	0.0895	0.1046	0.6689	0.9369	0.9960	0.5550	0.1928	0.0682	0.0410	0.0340	0.0312
Sk		1A	Bu	levee	0.0426	0.0493	0.3966	0.7171	0.9200	0.8953	0.5197	0.1952	0.0765	0.0406	0.0278

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

7. WITH PROJECT DAMAGES AND BENEFITS

This section describes how benefits of flood risk management for the Tentatively Selected Plan (TSP) were evaluated. Several alternatives were considered in the Final Array of Alternatives including the Comprehensive Urban Levee Alternative (CULI), the Joe Leary Bypass Alternative, and the Swinomish Bypass Alternative. These alternatives were screened based on a number of criteria including qualitative flood risk benefits, impacts to resources including agriculture, material quantities and relative cost. Each of the alternatives was assumed to provide protection for the 1% Annual Chance Exceedance (ACE) event (also known as the 100-year flood event, or a flood that has a 1% likelihood of occurring in any year). Based on this screening, only the Comprehensive Urban Levee Alternative was carried forward and resulted in the Tentatively Selected Plan. The other two alternatives had orders of magnitude greater cost and had negative impacts to environmental resources and the agricultural community. The CULI Alternative is the only alternative of the alternatives considered that is assumed to provide positive net benefits. See the main report for more information on the alternatives considered and the plan formulation process employed to screen the alternatives.

The CULI Alternative best addresses the study objectives and is the recommended TSP. As noted in the alternatives descriptions, the design goal of all the alternatives is to lower the 1% ACE flood elevations in the urban areas and provide 4-5 % ACE protection (existing level) to rural areas. The Joe Leary Slough and Swinomish Bypass Alternatives would provide increased flood protection in rural areas. These alternatives would require specialized outflow structures to divert flood flow that exceeds the river's capacity in less-frequent floods. Existing development in the bypasses would likely need to be removed and/or flood-proofed as depths and velocities within the bypass channels would be greater than in the without-project condition. The CULI Alternative is the alternative that is the most cost effective, has the least real estate impacts, has the least potential infrastructure impacts, has the least adverse impacts to environmental and agricultural resources, and is the most likely to be supported by the sponsor and the public. Evaluation and comparison of the final array of alternatives indicates that the bypasses alternatives are likely to have considerably higher construction and real estate costs than the CULI Alternative.

The floodplain depicted in Figure 8-1 is an approximate composite of the flooding that could occur from individual levee failures into each of the different portions of the floodplain if the CULI Alternative (1% ACE in defined urban areas) were to be implemented. Note that this degree of flooding is unlikely to occur during any single flood because a levee failure at one location may lower water surface elevations upstream and downstream, thus reducing risk of additional levee failures. This method of floodplain mapping has been chosen because it is not possible to reliably predict where a levee failure may occur during any individual flood. The TSP would reduce flood elevations in urban damage-reaches 1A, 4A, and 5A, and in rural damage-reaches 2 and 4. There would be induced flooding in rural areas 1, 6, and 6A.

As shown in the existing without-project condition, Reach 1 (Figure 6-3), which is the portion of the Skagit River floodplain north of SR 20, accounts for almost half (46%) of the potential damages. In the next phase of design, the study will evaluate the potential for structural options such as low levees within the floodplain and improvements to gates at the sea dikes, which could reduce some of these damages. There may be some opportunities to look at the possibilities for flood risk reduction in the communities of Allen, Edison, and Bow in greater detail. Significant structural measures would be needed to provide flood risk management to the entire floodplain. In order to reduce flooding in rural areas, river capacity would need to be significantly increased or bypasses constructed to handle the flow which exceeds the existing river capacity. This would be very expensive and could require improvements to all levees and possibly some bridge modifications to increase capacity. However, the rural floodplain in the northern Skagit River floodplain should be re-examined during design, as there may be some cost effective measures that could be implemented.

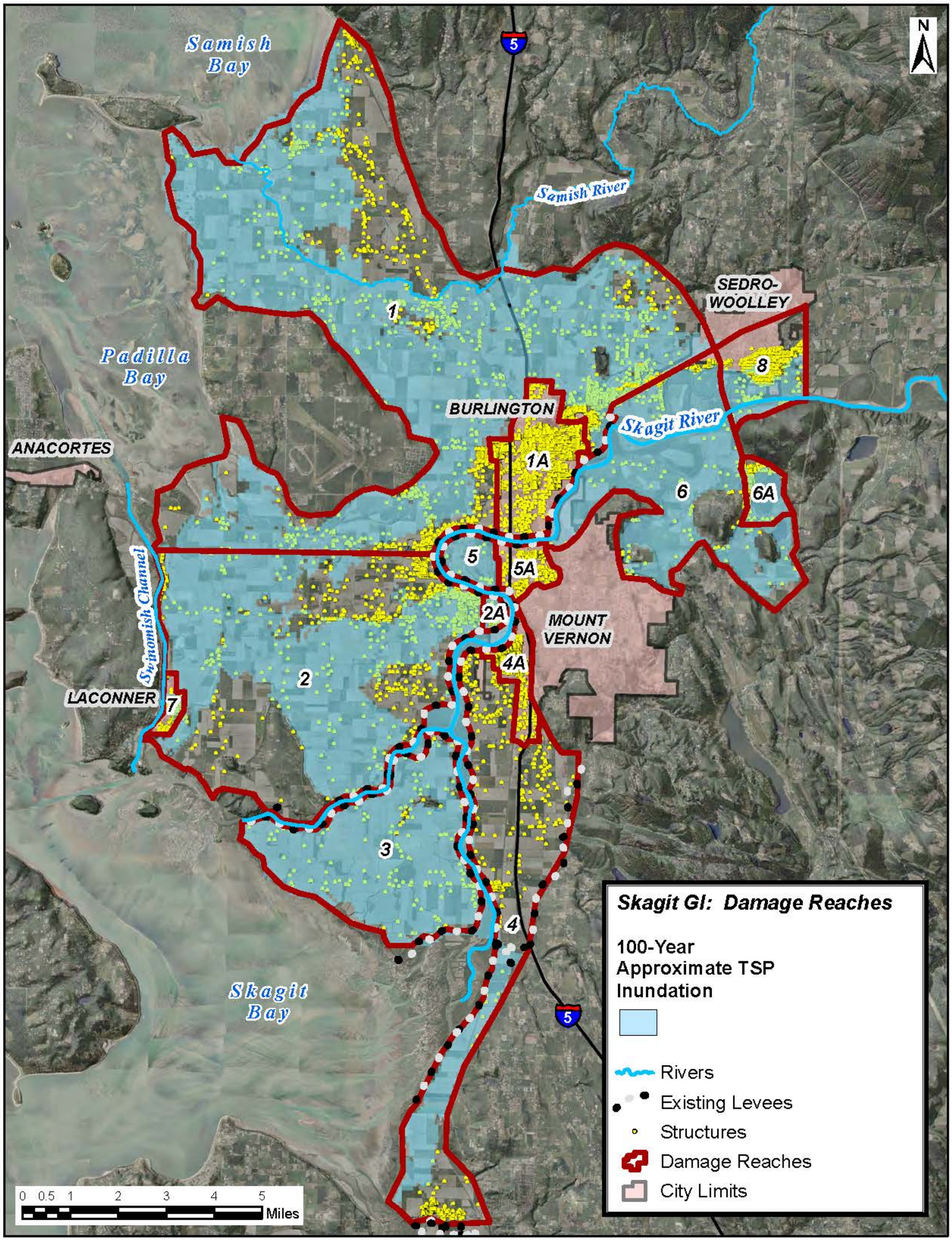

Figure 7-1. Comparison of Inundation for a 1% ACE Flood Inundation Under the Existing Condition (left) and Under the Recommended TSP (right)

The 1% ACE (100-year) event was used to evaluate and compare alternatives, and select the TSP. While it was assumed that 1% ACE protection to urban areas would greatly reduce flood risk and associated damages, the study team acknowledged that this protection may not reasonably maximize net benefits for National Economic Development (NED). Three scales of the CULI alternative were evaluated for benefits and costs to determine an appropriate scale to reasonably maximize net benefits, including roughly the 1.3% ACE level of protection (75-year), 1% ACE (100-year) protection, and 0.4% ACE (250-year) protection. Scaling of the features were based on the computed ACE and conditional non-exceedance probability (CNP), or the likelihood a reach would remain dry from a given ACE, with CNP greater than 90% for the target ACE in the Burlington-Mount Vernon urban areas. Baker Dam operational measures were evaluated as project features that could be added to any of the downstream alternatives. Hydraulic analyses of the Baker Dam operational measures were evaluated and carried forward into the hydraulic analysis of the CULI alternative, and the results of the hydraulic analysis and the estimated operational expenses are summarized in the following section. A map of project features associated with the CULI alternative is shown in Figure 8-2.

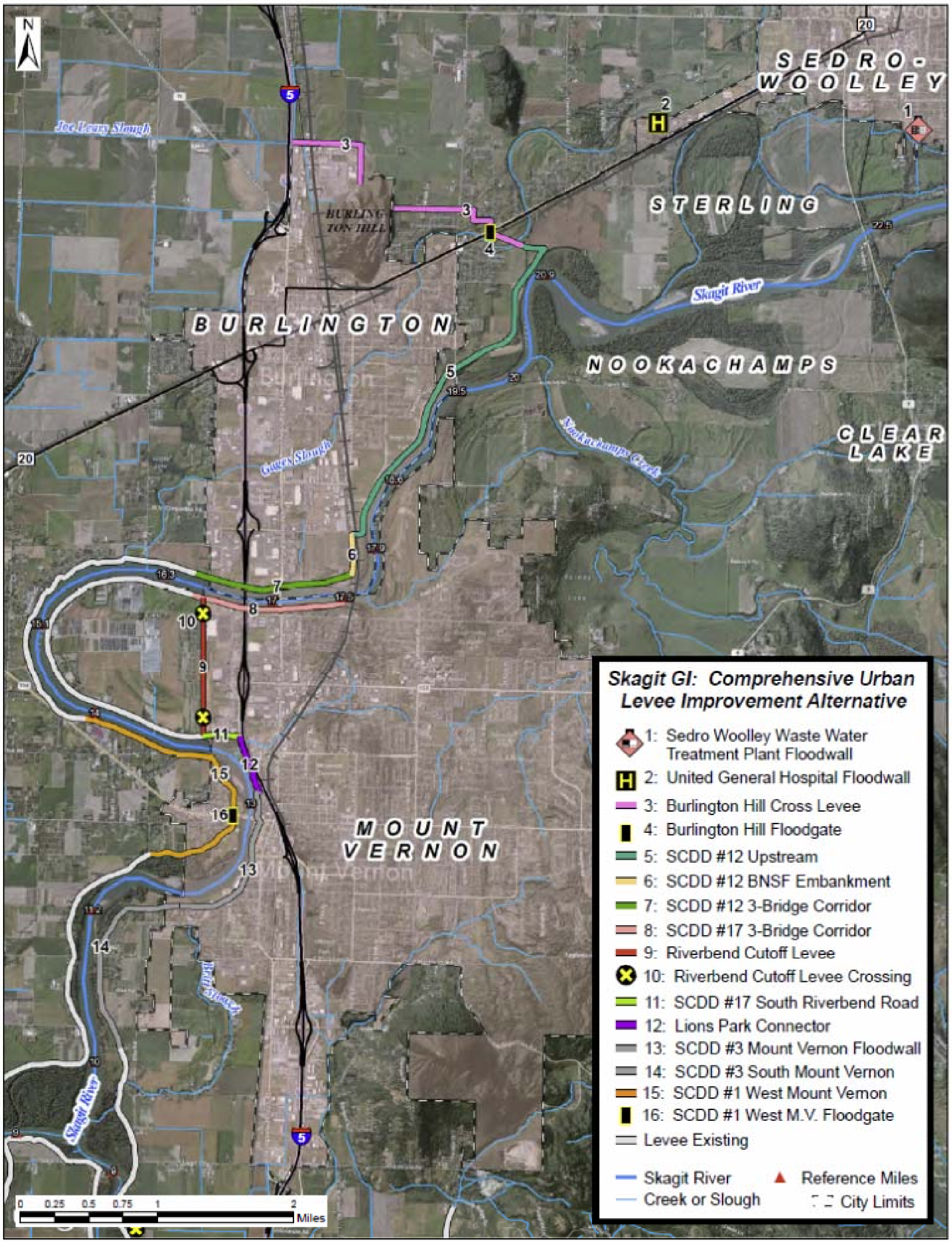

Figure 7-2. Skagit River Comprehensive Urban Levee Improvement Alternative

7.1 Optimization of TSP Plan for NED

The national or Federal objective of water and related land resources planning is to contribute to national economic development (NED). Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and to the rest of the nation. Ordinarily the plan that reasonably maximizes net benefits, known as the NED plan, is recommended.

This section documents the optimization of the tentatively selected plan (TSP) to reasonably maximize net benefits for NED. The 1% ACE (100-year) event was used to evaluate and compare alternatives, and identify the TSP. The Comprehensive Urban Levee Improvement (CULI) Alternative was identified based on a number of criteria and the environmental impacts assessment in Sections 3 and 4 of the main report. Based on evaluation and comparison of the final array of alternatives, the CULI Alternative was the only alternative in the final array of alternatives thought to provide positive net benefits. Three scales of the CULI Alternative were evaluated for benefits and costs to determine an appropriate scale to maximize net benefits, including protection from the 1% ACE, 1.3% ACE and 0.4% ACE event. These alternative scales were chosen to evaluate protection greater than existing protection and incremental changes in benefits and costs with increasing protection. Scaling of the features were based on the computed ACE and conditional non-exceedance probability (CNP), or the likelihood a reach would remain dry from a given ACE, with CNP greater than 90% for the target ACE in the Burlington-Mount Vernon urban areas. Hydraulic analyses of the Baker Dam operational measures were also conducted and carried forward into the hydraulic analysis of the CULI Alternative, and the results of the hydraulic analysis and the estimated operational expenses are summarized in the following section.

7.1.1 Baker Dam Optimization

The Upper and Lower Baker Dam Operational Modification Measure are included in the optimization of the TSP, CULI Alternative. The analysis examined early seasonal storage at Upper Baker Dam and flood storage at Lower Baker Dam, consistent with Article 107 in the Settlement Agreement for the Baker River Project. Upper Baker Dam is currently operated for flood control with full flood storage capacity of 74,000 acre feet available on November 15. The Upper Baker Dam operational measure includes flood storage capacity of 74,000 acre feet on October 15. Approximately 30 percent of floods occur between October 1 and November 15. Lower Baker Dam is operated with Upper Baker Dam for hydropower generation and currently is not operated for flood control. An analysis conducted by Puget Sound Energy (PSE) determined 20,000 acre feet of assured flood control space could be available during the October to March flood season. The TSP also includes 20,000 acre feet of storage at Lower Baker Dam from October 15 to March 1. Both dams were evaluated on their own and in combination. The flood discharge reductions from regulation at each dam were calculated for the Skagit River at Concrete. Those regulated flood hydrographs were then routed downstream through the study area and used to compute flood water surface elevations. The combination of both the Upper and Lower Baker Dam operational modification measure resulted in the greatest downstream benefit, with a 17,000 cfs flow reduction for the 1% ACE flood at Concrete and up to approximate a 1 foot stage reduction in the Nookachamps area. These measures are consistent with language in the Federal Energy Regulatory Commission (FERC) No. 2150 relicense dated October 17, 2008 which allows for additional flood control operations if a number of conditions are met, including compensation to PSE for forgone hydropower generation and dependable capacity. PSE estimates generation and dependable capacity losses to be approximately $861,000 on average each year using April 2012 energy prices. At this time, it is assumed that PSE would be compensated for these losses and is included as an annual economic expense.

7.1.2 Cost Estimates, Construction Schedules and Risks

A baseline cost estimate, developed using the 1% ACE hydraulic model, was developed to calculate to cost of the TSP. In order to determine the NED plan, two additional iterations were developed based on this baseline (1.33% ACE and 0.4% ACE). Table 7-1 summarizes project costs for three alternative scales, escalated to the year of anticipated authorization (first costs), which range from $196 million for 1.3% ACE protection to $220 million for 0.4% protection. The range in costs is largely due to changes in levee elevations from one scale to another, and thus differences in necessary materials and quantities. Table 5-1 summarizes all project costs (excluding O&M) that the Federal Government and Skagit County are expected to incur following Project Authorization. Costs are accounted for along a standardized work breakdown structure (WBS).

Conceptual level designs and parametric costs were used to develop the construction estimates, and at the same time identifying risk and uncertainties, using the risk-informed decision process. A primary intention at this stage is to provide a basis for identifying an appropriate NED plan for further development. Additionally, determining future costs is a goal. Conceptual level designs and parametric costs are appropriate for comparison purposes, and contributes to the higher contingency values. A detailed cost estimate based on feasibility-level design will be prepared later in the feasibility phase, and would be the basis of both the authorized cost, and the framework of cost sharing between the Federal Government and Skagit County.

Table 7-1. CULI Alternative Scale Project First Cost Estimates

WBS Feature & Sub-Feature Description (Oct 2015 prices)	**CULI 1.3% ACE Estimated Cost**	**CULI 1% ACE Estimated Cost**	**CULI 0.4% ACE Estimated Cost**
06 - Fish & Wildlife Facilities	$6,067,000	$6,089,000	$6,142,000
11 - Levees & Floodwalls	126,170,000	136,792,000	147,919,000
02 - Relocations	12,915,000	13,198,000	13,312,000
Construction Estimate Totals	***$140,174,000***	***$156,078,000***	***$167,373,000***
01 - Lands & Damages	$11,576,000	$11,576,000	$11,576,000
30 - Planning, Engineering & Design (PED)	29,325,000	29,325,000	29,325,000
31 - Construction Management	10,260,000	10,974,000	11,666,000
Project First Cost Totals	**$196,312,000**	**$207,954,000**	**$219,940,000**
Schedule Durations (months)	**25**	**25**	**27**
Construction Contingency	**63%**	**64%**	**65%**

The Cost Engineering Appendix (Appendix G) contains detailed discussions of how Table 8-1 was calculated. However, the figures above can be broken into three broad categories: construction costs (WBS 06, 11), real estate and relocation costs (01, 02), and design and administrative costs (30, 31).

Construction Cost Estimates

Construction cost estimates were based on conceptual designs and quantities prepared for each alternative scale. The largest single cost component is raising levees in urban areas. This is due to the volume of material required for construction. Other major cost drivers are the floodwalls and floodgates that protect critical infrastructure, as well as the new levees that would be constructed in North Burlington and at the Riverbend Cut-Off.

Real Estate and Relocation Costs

Land costs were developed by NWS Real Estate Division. They are meant to incorporate easements, lands, and all other minimum real estate acquisition costs required to support the proposed project. Additionally, both Federal and non-Federal Administrative cost projections were included to cover labor and other activities associated with acquiring the required real estate interests. (See Appendix F (Real Estate) for more details.)

A variety of relocations would be necessary in order to allow for new and improved levees and the protective floodwall features. The majority of these costs are due to road modifications. However, there are a number of utilities that may require relocation.. Exact utility locations and the necessity of relocating subject utilities will be further explored during the feasibility-level design phase. Initial utilities relocation cost estimates were developed by NWS Cost Engineering.

Design and Administrative Costs

These costs are meant to capture the cost of design and project management following authorization of the project. They do not include costs of General Investigation (feasibility phase) process. These numbers are based on estimates of similar large scale projects that the Seattle District has designed and implemented, and further refinement will take place later in the Feasibility Phase.

Construction Schedules

Following authorization of the project, completion of design, purchase of applicable real estate, and Following authorization of the project, completion of design, acquiring necessary real estate, and awarding the construction contract, actual construction would begin. Construction times vary between the three alternative scales, ranging between 25 and 27 months. Due to the project footprint, it is currently assumed that many project elements could be constructed in parallel, rather than sequentially. This allows for shorter construction duration, but this assumption is likely to change as project development proceeds. Currently, tasks other than construction activities are not incorporated into the schedule; however, during the Feasibility Phase a comprehensive schedule dealing with all tasks following project authorization will be prepared.

Construction Risks & Contingency

Construction risks play a role in determining overall costs as these risks are used in determining contingency. The largest risk to this project is related to changes in raising levees in urban areas. Levees represent the single largest piece of project cost, and minor variations to this feature could have large implications for the project cost. While the PDT is largely confident in the overall prism, there is the potential that portions of levee will be converted to flood wall, height increases in localized segments of the levee, increases in protective armoring based on hydraulic conditions, or that interferences with existing structures and property will require changes to the footprint. Other components of risk that drive contingency include uncertainty regarding site conditions and staging areas, the need for floodwalls to include piling to prevent overturning, and the use of conceptual designs that may change to incorporate more information as the project develops. Contingency is developed scientifically and methodically using the risks as documented by the PDT, along with the team's understanding of the likelihood of an eventuality occurring and the overall impact to the project. Further detail is available in the Cost Engineering Appendix.

Operations and Maintenance

A comprehensive operations and maintenance (O&M) cost estimate will be prepared during the Feasibility Phase. Currently items incorporated this include: new floodwalls, and USACE water management operations of the Baker Dam project during the flood season. Annual O&M of the CULI Alternative are assumed to be the same across scales.

7.1.3 Economic Costs

Economic costs were based on present value cost estimates at the September 2013 price level. Expenditures or financial outlays made during the construction of alternatives are made with no immediate return on investment. Those financial outlays could have otherwise been invested elsewhere and begin returns on investment immediately. The forgone return on investment is an opportunity cost of the alternative and is computed as interest during construction. Interest during construction (IDC) was estimated using the estimated construction duration and current Federal discount rate. IDC was added to the estimated project costs to determine the total investment cost of each CULI Alternative scale, as shown in Table 7-2. Annual O&M costs of the CULI Alternative are assumed to be the same across scales. New O&M with the CULI Alternative includes new levees, new floodwalls, and USACE water management operations of the Baker Dam project during the flood season are described in the main report.

Table 7-2. CULI Alternative Scale Cost Summaries

	CULI 1.3% ACE	CULI 1% ACE	CULI 0.4% ACE
Present Value Cost (September 2013 prices)	$196,312,000	$207,954,000	$219,940,000
Interest During Construction	$6,914,000	$7,324,000	$7,747,000
Total Investment Cost	$203,226,000	$215,278,000	$227,687,000
Period of Analysis (Years)	50	50	50
Discount Rate (FY14)	3.50%	3.50%	3.50%
Annual Cost of Initial Investment	$8,664,000	$9,178,000	$9,707,000
Annual Cost of Baker Storage Compensation	$861,000	$861,000	$861,000
Annual O&M of New FRM Features and Additional Flood Regulation	$40,000	$40,000	$40,000
Total Annual Cost	$9,565,000	$10,079,000	$10,608,000

7.1.4 Benefits

Expected annual damages (EAD) of each of the CULI Alternative scales were compared to the without-project condition EAD estimate of $40 million as shown in Table 7-3. Damages were reduced to urban development in Burlington (1A), Mount Vernon (2A, 4A, and 5A) and La Conner (7) with the CULI Alternative, with potentially minor induced flood damages to Sedro-Woolley (Reach 8), Nookachamps (6), Clear Lake (6A), and the broad northern Skagit floodplain (1). The 0.4% ACE CULI Alternative scale provided the greatest damage reduction of $19.8 million annually, or approximately a 50% reduction in expected annual flood damages. This table also includes a display of the residual risk, or the flood damage that remains if a proposed flood damage reduction project is implemented.

Additionally, the population at risk from flooding is reduced from approximately 37,000 in the without project condition to 21,000 in the with project condition.

Table 7-3. EAD Reductions by Alternative Scale ($1,000s)

Damage Reach(es)	Without-project EAD	CULI 1.3% ACE		CULI 1% ACE		CULI 0.4% ACE	
		EAD (Residual Risk)	Benefits (EAD Reduced)	EAD (Residual Risk)	Benefits (EAD Reduced)	EAD (Residual Risk)	Benefits (EAD Reduced)
Upper Right Bank Skagit Floodplain - 1	$9,915	$9,626	$289	$9,626	$289	$9,626	$289
Burlington – 1A	14,737	2,925	11,812	1,770	12,967	955	13,782
Lower Right Bank Floodplain - 2	4,429	3,083	1346	2,728	1,701	2,606	1,823
West Mount Vernon – 2A	496	117	380	33	464	4	492
Fir Island – 3	727	727	0	727	0	727	0
Lower Left Bank Floodplain – 4	2,348	2,348	0	2,348	0	2,348	0
Mount Vernon – 4A	1,760	406	1,354	94	1,665	12	1,747
River Bend – 5	34	5	30	4	31	2	32
North Mount Vernon – 5A	1,484	314	1,170	211	1,272	83	1,401
Nookachamps – 6	2,003	1,981	22	1,981	22	1,981	22
Clear Lake – 6A	555	543	12	543	12	543	12
La Conner – 7	872	283	589	134	738	86	786
Sedro-Woolley - 8	540	1,142	-602	1,142	-602	1,142	-602
Total	$39,899	$23,498	$16,401	$21,341	$18,558	$20,114	$19,785

7.1.5 Engineering Performance

This section includes a summary of the project performance and long-term risk associated with the project. Table 7-4 displays the expected annual exceedance probability for the without project condition and the three CULI scales.

Table 7-4. Expected Annual Exceedance Probability by Plan

Damage Reach(es)	Expected Annual Exceedance Probability			
	Without Project	CULI 1.3% ACE	CULI 1% ACE	CULI 0.4% ACE
Burlington (Reach 1A)	5%	1%	0.3%	0.1%
Mount Vernon (Reaches 2A, 4A, and 5A)	4%	1%	1%	0%
La Conner (Reach 7)	4%	1%	1%	0%
Rural Floodplain (all other reaches)	4-61%	0.2-61%	0.1-61%	0-61%

It should be noted that the performance of the Mount Vernon floodwall in Reach 4A is dependent on both upstream and downstream measures. It was designed to provide at least 1% ACE protection and in combination with the CULI measures provides at least 1% ACE protection (and at least 0.4% ACE protection for the CULI 0.4% ACE plan) as is reflected in the annual exceedance probabilities for Mount Vernon as shown in Table 7-4.

Table 7-5 displays the long-term risk in a 30 year period (a typical mortgage duration) for the without project condition and the three CULI scales.

Table 7-5. Long-Term Risk (30 years) by Plan

Damage Reach(es)	Long-Term Risk (30 years)			
	Without Project	**CULI 1.3% ACE**	**CULI 1% ACE**	**CULI 0.4% ACE**
Burlington (Reach 1A)	72%	13%	7%	3%
Mount Vernon (Reaches 2A, 4A, and 5A)	64%	14%	2%	0.2%
La Conner (Reach 7)	68%	15%	3%	0.4%
Rural Floodplain (all other reaches)	67-100%	4-100%	3-100%	0.8-100%

Table 7-6 below shows the CNP's for the without project condition and three CULI scales assuming the 1% ACE event occurs. These values are good indicators of a project's performance because it takes into consideration the uncertainty in the discharge-probability and stage-discharge estimates.

Table 7-6. Conditional Non-Exceedance Probability (CNP) for the 1% ACE Event by Plan

Damage Reach(es)	Conditional Non-Exceedance Probability (CNP) for the 1% ACE Event			
	Without Project	**CULI 1.3% ACE**	**CULI 1% ACE**	**CULI 0.4% ACE**
Burlington (Reach 1A)	8%	84%	92%	97%
Mount Vernon (Reaches 2A, 4A, and 5A)	21%	81%	97%	99.7%
La Conner (Reach 7)	22%	77%	95%	99.4%
Rural Floodplain (all other reaches)	0-35%	0-94%	0-96%	0-99%

Additional estimates of annual exceedance probability, long-term risk for the 10 and 50-year time periods, and conditional non-exceedance probabilities for the 10%, 4%, 2%, 0.4%, and 0.2% are given for each scale of the CULI alternative in Table 7-7 through Table 7-9 below.

Table 7-7. Project Performance for the 1.3% ACE CULI Alternative

Project Performance

File Help

Skagit River GI Project Performance
by Damage Reaches for the CULI_75yr
() plan for Analysis Year 2013
(Stages in ft.)
Plan was calculated with Uncertainty

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

					Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Skagit DR1A		1A	Burlington	levee	0.0030	0.0055	0.0532	0.1278	0.2393	0.9999	0.9974	0.9296	0.8399	0.5988	0.4007
Skagit DR2A		2A	West Mt Vernon	levee	0.0027	0.0066	0.0639	0.1523	0.2814	0.9998	0.9939	0.8831	0.7664	0.5742	0.4931
Skagit DR5		5	River Bend	levee	0.0001	0.0018	0.0178	0.0440	0.0861	1.0000	0.9998	0.9791	0.9400	0.8335	0.7856
Skagit DR5A		5A	North Mt Vernon	levee	0.0001	0.0018	0.0178	0.0438	0.0857	1.0000	0.9998	0.9791	0.9399	0.8334	0.7856
Skagit DR6		6	Nookachamps	levee	0.4660	0.6107	0.9999	1.0000	1.0000	0.0293	0.0012	0.0001	0.0000	0.0000	0.0000
Skagit DR6A		6A	Clear Lake	levee	0.4660	0.6108	0.9999	1.0000	1.0000	0.0293	0.0012	0.0001	0.0000	0.0000	0.0000
Skagit DR7		7	La Conner	levee	0.0027	0.0066	0.0639	0.1521	0.2810	0.9998	0.9939	0.8834	0.7669	0.5747	0.4936
Skagit DR8		8	Sedro Wolley	47.06	0.0895	0.1057	0.6729	0.9388	0.9963	0.5550	0.1923	0.0506	0.0201	0.0016	0.0003
Skagit DR_2		2	Lower Right Bank Fl	levee	0.0027	0.0066	0.0639	0.1523	0.2814	0.9998	0.9938	0.8831	0.7664	0.5743	0.4931
Skagit River NF	North Fork of th	3	Fir Island	levee	0.0597	0.0629	0.4776	0.8028	0.9611	0.7469	0.4231	0.2551	0.1957	0.1750	0.1619
Skagit River SF	South Fork of tl	4	Lower Left Bank Floc	levee	0.1328	0.2026	0.8961	0.9965	1.0000	0.3693	0.0778	0.0205	0.0143	0.0133	0.0131
Skagit-Dam_Rc		1	Damage Reach 1	levee	0.0377	0.0455	0.3725	0.6880	0.9027	0.8979	0.5882	0.2554	0.1433	0.0378	0.0155
SkagitRiverDR		4A	Mt. Vernon	levee	0.0023	0.0061	0.0594	0.1419	0.2637	0.9993	0.9855	0.8890	0.8137	0.6556	0.5059

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Table 7-8. Project Performance for the 1% ACE CULI Alternative

Project Performance

File Help

Skagit River GI Project Performance
by Damage Reaches for the CULI_100yr_2
(Burlington +6ft) plan for Analysis Year 2013
(Stages in ft.)
Plan was calculated with Uncertainty

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

					Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Skagit DR1A		1A	Burlington	levee	0.0018	0.0030	0.0295	0.0721	0.1391	1.0000	0.9993	0.9697	0.9245	0.7573	0.5813
Skagit DR2A		2A	West Mt Vernon	levee	0.0001	0.0014	0.0139	0.0345	0.0678	1.0000	0.9996	0.9772	0.9460	0.8756	0.8344
Skagit DR5		5	River Bend	levee	0.0001	0.0010	0.0103	0.0256	0.0506	1.0000	0.9999	0.9872	0.9616	0.8865	0.8505
Skagit DR5A		5A	North Mt Vernon	levee	0.0001	0.0010	0.0102	0.0253	0.0499	1.0000	0.9999	0.9872	0.9617	0.8865	0.8505
Skagit DR6		6	Nookachamps	levee	0.4660	0.6107	0.9999	1.0000	1.0000	0.0293	0.0012	0.0001	0.0000	0.0000	0.0000
Skagit DR6A		6A	Clear Lake	levee	0.4660	0.6108	0.9999	1.0000	1.0000	0.0293	0.0012	0.0001	0.0000	0.0000	0.0000
Skagit DR7		7	La Conner	levee	0.0001	0.0014	0.0139	0.0345	0.0678	1.0000	0.9996	0.9772	0.9460	0.8756	0.8344
Skagit DR8		8	Sedro Wolley	47.06	0.0895	0.1057	0.6729	0.9388	0.9963	0.5550	0.1923	0.0506	0.0201	0.0016	0.0003
Skagit DR_2		2	Lower Right Bank Fl	levee	0.0001	0.0014	0.0139	0.0345	0.0678	1.0000	0.9996	0.9772	0.9460	0.8756	0.8344
Skagit River NF	North Fork of th	3	Fir Island	levee	0.0597	0.0629	0.4776	0.8028	0.9611	0.7469	0.4231	0.2551	0.1957	0.1750	0.1619
Skagit River SF	South Fork of tl	4	Lower Left Bank Floc	levee	0.1328	0.2026	0.8961	0.9965	1.0000	0.3693	0.0778	0.0205	0.0143	0.0133	0.0131
Skagit-Dam_Rc		1	Damage Reach 1	levee	0.0377	0.0455	0.3725	0.6880	0.9027	0.8979	0.5882	0.2554	0.1433	0.0378	0.0155
SkagitRiverDR		4A	Mt. Vernon	levee	0.0001	0.0010	0.0096	0.0239	0.0472	0.9999	0.9989	0.9830	0.9665	0.9100	0.8338

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Table 7-9. Project Performance for the 0.4% ACE CULI Alternative

Project Performance

File Help

Skagit River GI Project Performance
by Damage Reaches for the CULI_250yr
() plan for Analysis Year 2013
(Stages in ft.)
Plan was calculated with Uncertainty

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

					Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Skagit DR1A		1A	Burlington	levee	0.0001	0.0012	0.0124	0.0307	0.0604	1.0000	0.9999	0.9892	0.9697	0.8751	0.7494
Skagit DR2A		2A	West Mt Vernon	levee	0.0001	0.0001	0.0014	0.0035	0.0070	1.0000	1.0000	0.9979	0.9944	0.9834	0.9752
Skagit DR5		5	River Bend	levee	0.0001	0.0003	0.0033	0.0082	0.0164	1.0000	1.0000	0.9959	0.9866	0.9547	0.9376
Skagit DR5A		5A	North Mt Vernon	levee	0.0001	0.0003	0.0033	0.0082	0.0164	1.0000	1.0000	0.9959	0.9867	0.9547	0.9376
Skagit DR6		6	Nookachamps	levee	0.4660	0.6107	0.9999	1.0000	1.0000	0.0293	0.0012	0.0001	0.0000	0.0000	0.0000
Skagit DR6A		6A	Clear Lake	levee	0.4660	0.6108	0.9999	1.0000	1.0000	0.0293	0.0012	0.0001	0.0000	0.0000	0.0000
Skagit DR7		7	La Conner	levee	0.0001	0.0001	0.0014	0.0035	0.0070	1.0000	1.0000	0.9979	0.9944	0.9834	0.9752
Skagit DR8		8	Sedro Wolley	47.06	0.0895	0.1057	0.6729	0.9388	0.9963	0.5550	0.1923	0.0506	0.0201	0.0016	0.0003
Skagit DR_2		2	Lower Right Bank Fl	levee	0.0001	0.0001	0.0014	0.0035	0.0070	1.0000	1.0000	0.9979	0.9944	0.9834	0.9752
Skagit River NF	North Fork of th	3	Fir Island	levee	0.0597	0.0629	0.4776	0.8028	0.9611	0.7469	0.4231	0.2551	0.1957	0.1750	0.1619
Skagit River SF	South Fork of th	4	Lower Left Bank Floc	levee	0.1328	0.2026	0.8961	0.9965	1.0000	0.3693	0.0778	0.0205	0.0143	0.0133	0.0131
Skagit-Dam_Rc		1	Damage Reach 1	levee	0.0377	0.0455	0.3725	0.6880	0.9027	0.8979	0.5882	0.2554	0.1433	0.0378	0.0155
SkagitRiverDR		4A	Mt. Vernon	levee	0.0001	0.0001	0.0008	0.0021	0.0042	1.0000	0.9999	0.9988	0.9974	0.9889	0.9733

****** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

7.1.6 Benefit-Cost Analysis

Total annual benefits, or expected annual damage reductions, were analyzed with total annual costs to determine net benefits and benefit-cost ratios as summarized below in Table 7-10. Net benefits are equal to the total annual benefits minus total annual costs. Benefit-cost ratios (BCRs) are equal to total annual benefits divided by total annual costs. All CULI Alternative scales resulted in positive net benefits and benefit-cost ratios greater than 1. The 1% ACE CULI Alternative scale removes 3,736 properties from the 1% floodplain and the 0.4% CULI Alternative scale removes 3,942 properties from the 1% floodplain. The 0.4% ACE CULI Alternative scale provided the greatest contributions to National Economic Development (NED) as it maximizes net benefits (annual benefits less annual costs) at $9.2 million and results in the greatest benefit-cost ratio of 1.9.

Table 7-10. Benefit-Cost Ratio and Net Benefit Evaluations for CULI Alternative

	CULI 1.3% ACE	CULI 1% ACE	CULI 0.4% ACE
Total Investment Cost (Sep 2013 price level)	$203,226,000	$215,278,000	$227,687,000
Total Annual Cost	$9,565,000	$10,079,000	$10,608,000
Total Annual Benefits	$16,401,000	$18,558,000	$19,785,000
Net Benefits	$6,836,000	$8,479,000	$9,177,000
Benefit-Cost Ratio (at 3.5% discount rate)	1.7	1.8	1.9
Benefit-Cost Ratio (at 7% discount rate)	1.02	1.09	1.10

Alternative scales greater than the 0.4% ACE scale were not considered for analysis of net benefits. Larger levees and further confinement of flood waters would likely induce impacts, and transform and transfer risk to both the levee protected areas as well as levees on the North and South Forks of the Skagit River. Containing more flow in the river at Burlington and Mount Vernon would increase flows downstream, which would increase overtopping and could necessitate further levee improvements (raises or setbacks) to accommodate this transfer of risk.

7.1.7 NED Plan Selection

While the floodplain is the same for either the 1% or 0.4% ACE scale, the 0.4% ACE scale further reduces flood frequency to critical infrastructure and the long-term risk to protected areas based on existing flood hydrology. The 1% ACE scale provided greater incremental net benefits at $1.6 million when going from the 1.3% ACE scale to the 1% ACE scale. The incremental net benefits for the 0.4% ACE scale at $698,000. This suggests that benefits are increasing at a lower rate than the increase in cost after the 1% scale. However, the 0.4% ACE scale provides greater protection and long-term risk reduction. Over thirty years, the probability of inundation decreases by approximately half when going from the 1% ACE to 0.4% ACE scale project for the most heavily populated areas. Additionally, going from the 1% ACE to 0.4% ACE scale provides the project greater resilience against predicted future climate change impacts that will increase flood frequencies. The 0.4% ACE CULI alternative scale provided the greatest contributions to National Economic Development (NED) as is thought to maximize net benefits (annual benefits less annual costs) at $9.2 million and results in the greatest benefit-cost ratio of 1.9, and provide increased life safety improvements. The NED plan would protect approximately 16,000 people in the cities of Burlington, Mount Vernon, and La Conner, as well as United General Hospital and the Sedro-Woolley Wastewater Treatment Plant located outside of city limits.

The NED alternative will continue to be refined and undergo further analysis during feasibility-level design. It would be possible to revise the recommended NED plan from the more conservative 0.4% ACE scale to the 1% ACE scale as a result of these refinements, but differences are expected to be minor.

An additional consideration of the NED selection is climate change impacts. Climate change has been identified as a concern by local stakeholders and the tribes in the Skagit River Basin. The hydrologic impacts of climate change are uncertain and the science is still evolving. USACE has not established a procedure for addressing potential hydrologic changes caused by future climate change; however, a sensitivity analysis was completed to consider the effects of climate change. The results show that an important climate change related factor is that if we design for the 1% ACE flood and flood discharges do increase as predicted by Skagit River Basin Climate Science Report (SRBCSR 2011), the CULI Alternative will not provide 1% ACE protection over the 50-year project life. If we design for the 0.4% ACE scale, the urban areas would most likely still benefit from a 1% ACE protection over the 50-year project life and the benefits associated with the proposed Federal action would still be largely realized. Impacts of sea-level rise do not extend upstream to the urban areas protected by the CULI Alternative. The maximum sea-level rise is expected to be 2.15 feet, with a dampening of sea level rise of zero feet near the confluence of the North Fork and South Fork Skagit River distributaries downstream of the urban areas.

Table 7-11 summarizes the project first costs (constant dollar basis at the October 2015 price level) and the cost sharing for the NED Plan. The project first cost is estimated at $225,590,000 and the fully funded cost estimate is estimated at $243,922,000. The fully funded cost estimate accounts for cost inflation through the mid-point of construction. Assuming the project is authorized in the first quarter of FY 2016, the mid-point of construction is expected in the first quarter of 2019. Lands, easements, right-of-ways, relocations, and disposals (LERRDs or Lands & Damages, and Relocations) are credited towards the non-Federal sponsor's 35 percent cost share responsibility. The Federal and non-Federal shares are estimated $146,634,000 and $78,957,000, respectively.

Table 7-11. NED Plan: CULI 0.4% ACE Cost Estimate

First Costs (1 Oct 2015 price level)	Federal	Non-Federal	Total
Flood Risk Management			
Lands & Damages		$11,845,000	$11,845,000
Fish & Wildlife Facilities	$6,285,000		6,285,000
Levees & Floodwalls	151,348,000		151,348,000
Relocations		13,621,000	13,621,000
Planning, Engineering & Design	30,548,000		30,548,000
Construction Management	11,943,000		11,943,000
Minimum 5% Cash Contribution		12,196,000	
Cash Contribution	-53,491,000	42,211,000	
Total Project Cost Share	**$146,634,000**	**$78,957,000**	**$225,590,000**
Total Project Cost Share (%)	65%	35%	100%

7.2 NED Plan Residual Risk and Performance

Residual risk is the risk remaining after implementation of the plan. Each of the CULI Alternative scales, including the NED, leave some amount of residual risk in the floodplain. Much of the floodplain not concentrated in the urban areas remain at risk of flooding, including properties, agricultural lands, and critical infrastructure. Although risk is reduced to urban areas with improved levees, the risk levee failure poses to these same areas could be catastrophic if people remain in harm's way and are not able to receive ample warning to evacuate. Under the CULI Alternative, the 1% ACE flood elevations may increase by about 1 foot in the Nookachamps Basin. The floodplain overflow at Sterling would increase by 10,000-15,000 cfs, with all the floodwaters flowing north towards Padilla Bay. This increase in Sterling overflow could cause a 1/2 – 3/4 foot rise in 1% ACE flood elevations the northern floodplain.

Risk mitigation measures were included in this alternative, such as floodwalls for the United General Hospital and Sedro-Woolley Sewer Treatment Plant in Sedro-Woolley, which are not otherwise protected by levees or other flood infrastructure, or nonstructural measures. The United General Hospital serves eastern Skagit County. Another hospital is located in Mount Vernon outside of the floodplain. In the event of a flood, these facilities could become isolated until flood waters recede. Additionally, emergency access to the hospital, as well as emergency evacuation routes from communities upstream of Burlington to areas of safety, would continue to flood.

Other infrastructure that remains at risk with this alternative includes the major transportation routes I-5, SR 20, and SR 9 which could be closed during flood events. I-5 has not historically flooded from the Skagit River, but has flooded near Centralia from the Chehalis in 2007 and 2009 approximately 150 miles south of Mount Vernon, resulting in closure of a 20 mile stretch of I-5 for up to four days. The BNSF Railroad risks overtopping and pipeline operations may be impacted from floods of 1% ACE or a lesser chance of occurrence. However, BNSF operations would be halted during operations of the Mount Vernon Floodwall which includes a stop log across the railroad to tie in to high ground. The northern Skagit and Samish floodplain would still flood from both the Skagit River near Sterling and the Samish River, as indicated above.

Evacuation preparation can be made 2-3 days in advance of predictable flood events. As river stages rise and are predicted to reach flood stages, warnings could be reiterated and evacuation efforts increased. This would allow for evacuation of immobile residents and other people with special evacuation needs (hospital patients, assisted living facility residents, and elderly individuals) by way of emergency evacuation routes.

Flood fighting may affect the performance of the CULI Alternative if activities confine flood flows and allow for more water to reach downstream areas where levees could be at risk of overtopping and failure which include the urban centers protected by this alternative.

7.3 Risk and Uncertainty

Risk and uncertainty is fundamental to all water resource planning and communication. This study incorporated risk management framework principles and risk-informed planning into its plan formulation process.

- The hydrologic impacts of Climate Change are uncertain. If the changes discussed in Section **Error! Reference source not found.** were to occur, the level of protection provided by the CULI Alternative could fall from 0.4% ACE to 1% ACE over the 50 year period of analysis.
- Risk analysis and communication was used following ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies, and EM 1110-2-1619, Risk-Based Analysis for Flood Risk Management.
- Uncertainty was captured through cost engineering’s mandatory center of expertise (MCX) risk assessment project to establish cost contingencies. Risks to project cost and schedule were documented in an abbreviated cost and schedule risk assessment.

- Risks were assessed and managed throughout the study process, in coordination with the USACE Vertical Team.

Specific risk and uncertainty remaining includes the extent of potential induced and transferred flood risk resulting from confined flood flows with larger and more robust levees to areas in the northern Skagit River floodplain, including the Nookachamps-Clear Lake area and Sedro-Woolley, and downstream below Mount Vernon. To minimize and mitigate these uncertainties, more detailed hydraulic modeling of the CULI Alternative will be needed to better understand the flood risks associated with larger and more robust levees to other areas in the floodplain. Nonstructural measures such as elevating homes, relocations, developing evacuation routes and plans, as well as structural measures such as low elevation berms and improvements to interior drainage and sea dikes, can be evaluated on an incremental basis to reduce induced and/or residual flood risks once the risk is better understood.

8. CONCLUSIONS

The Tentatively Selected Plan (TSP) will be determined based upon NED and the evaluation of other metrics developed for the Skagit River Study. Please refer to the main report for detailed discussion of the metrics used to select the TSP.

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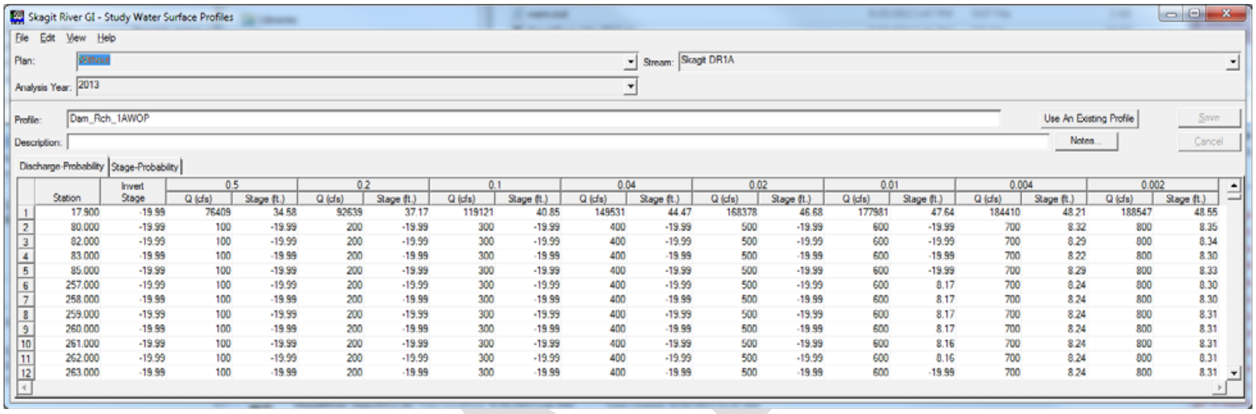
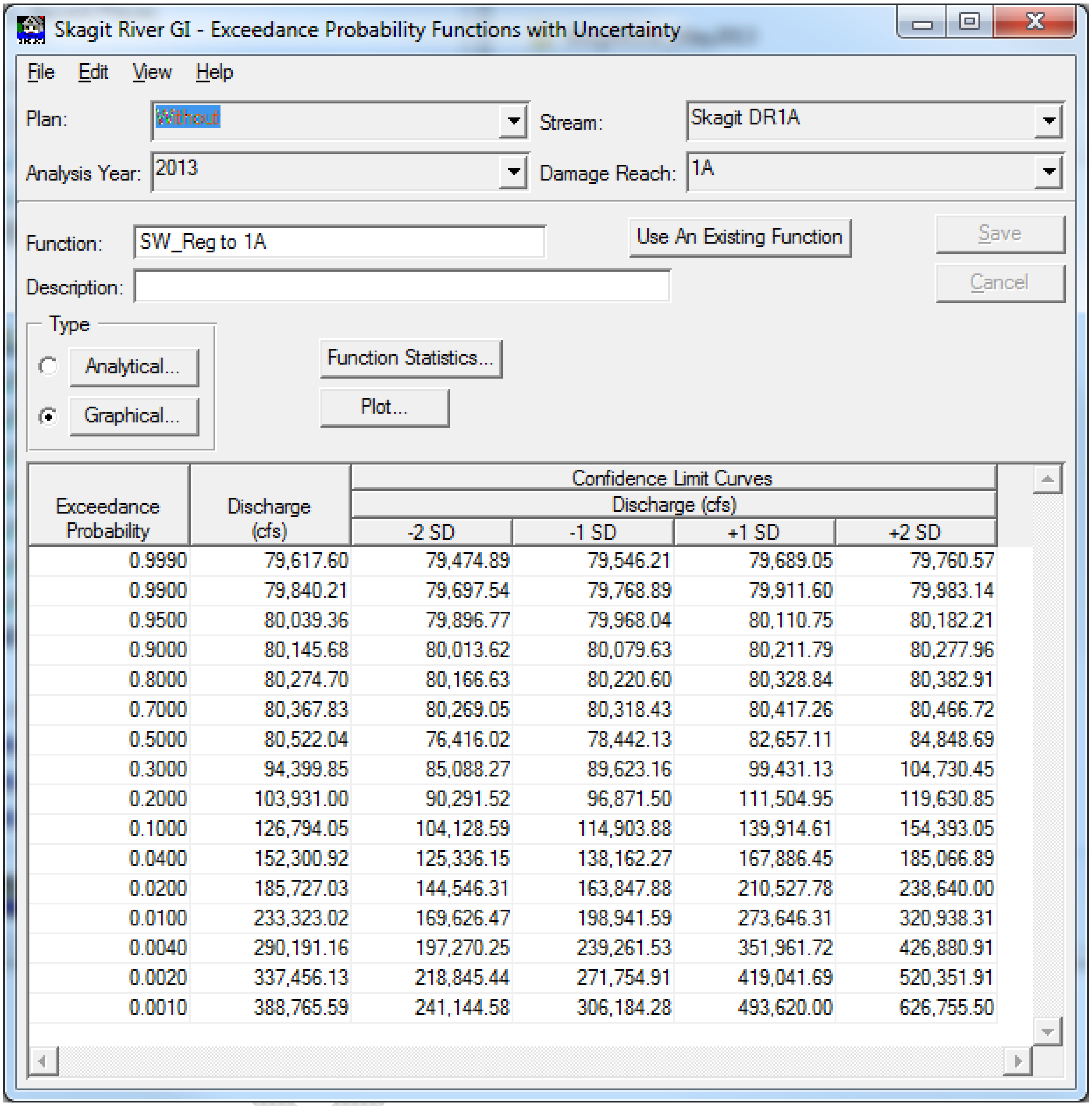
ATTACHMENTS

Attachment - HEC-FDA Model Inputs

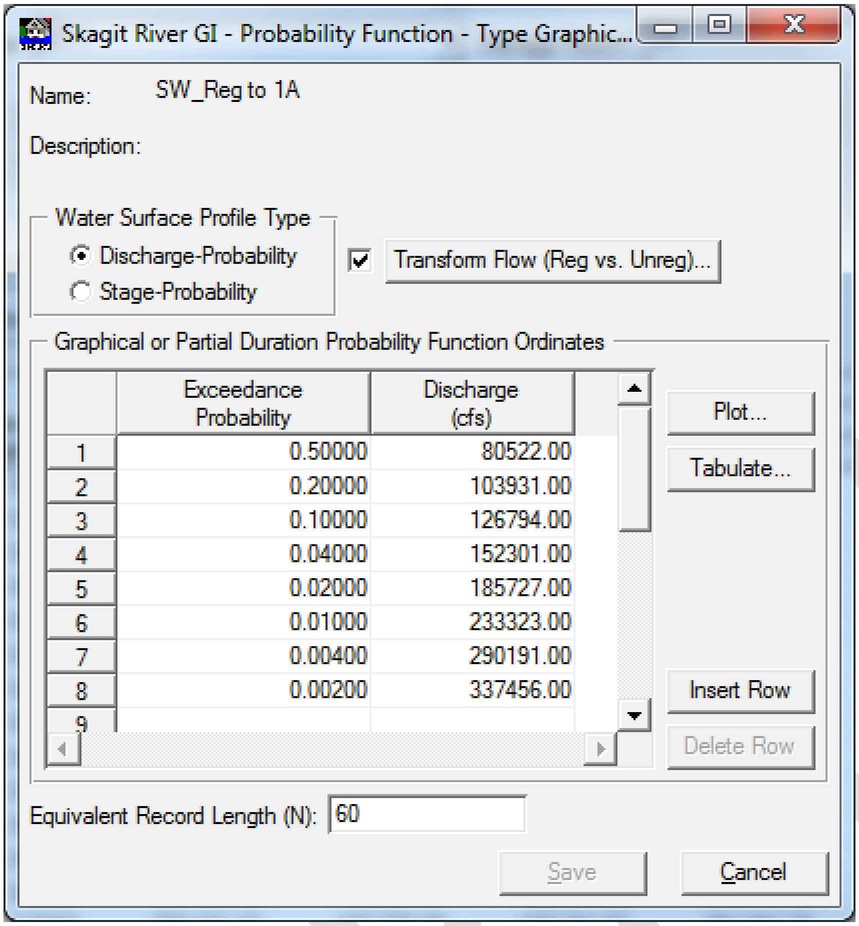
Hydrology and Hydraulics Inputs



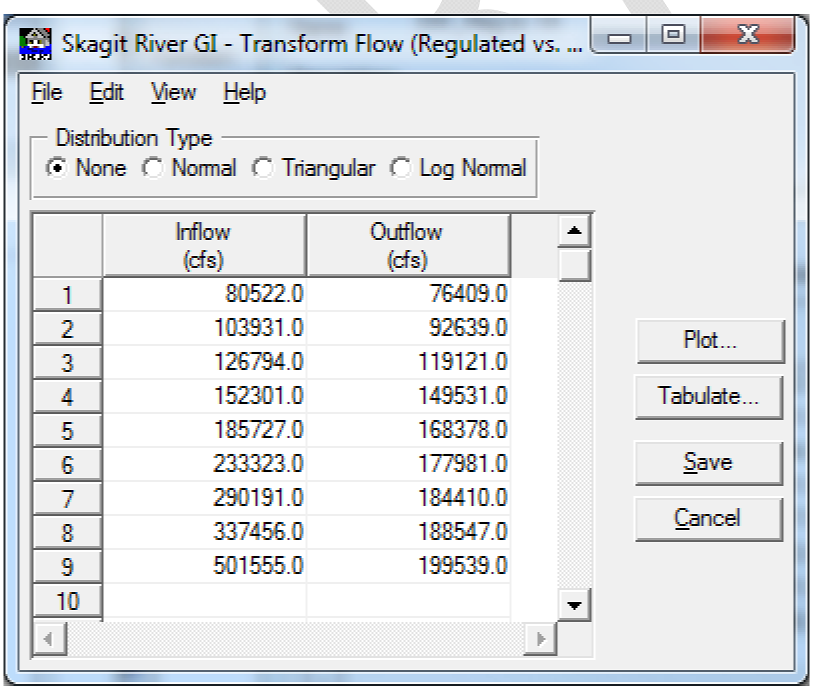
	Station	Invert Stage	0.5		0.2		0.1		0.04		0.02		0.01		0.004		0.002	
			Q (cfs)	Stage (ft.)	Q (cfs)	Stage (ft.)	Q (cfs)	Stage (ft.)	Q (cfs)	Stage (ft.)	Q (cfs)	Stage (ft.)	Q (cfs)	Stage (ft.)	Q (cfs)	Stage (ft.)	Q (cfs)	Stage (ft.)
1	17.900	-19.99	76409	34.58	92639	37.17	119121	40.85	149531	44.47	168378	46.68	177981	47.64	184410	48.21	188547	48.55
2	80.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	-19.99	700	8.32	800	8.35
3	82.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	-19.99	700	8.29	800	8.34
4	83.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	-19.99	700	8.22	800	8.30
5	85.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	-19.99	700	8.29	800	8.33
6	257.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	8.17	700	8.24	800	8.30
7	258.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	8.17	700	8.24	800	8.30
8	259.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	8.17	700	8.24	800	8.31
9	260.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	8.17	700	8.24	800	8.31
10	261.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	8.16	700	8.24	800	8.31
11	262.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	8.16	700	8.24	800	8.31
12	263.000	-19.99	100	-19.99	200	-19.99	300	-19.99	400	-19.99	500	-19.99	600	-19.99	700	8.24	800	8.31



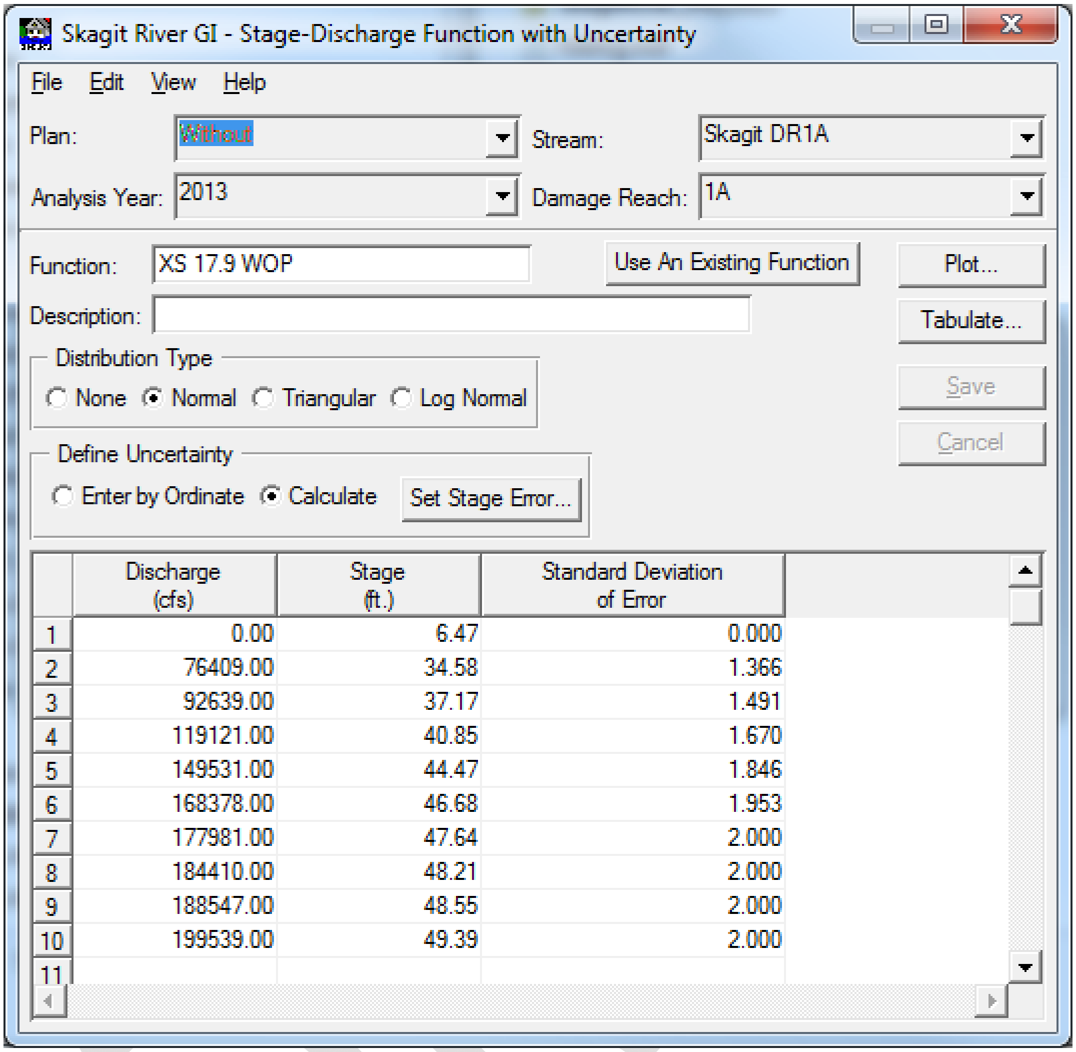
Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs)			
		-2 SD	-1 SD	+1 SD	+2 SD
0.9990	79,617.60	79,474.89	79,546.21	79,689.05	79,760.57
0.9900	79,840.21	79,697.54	79,768.89	79,911.60	79,983.14
0.9500	80,039.36	79,896.77	79,968.04	80,110.75	80,182.21
0.9000	80,145.68	80,013.62	80,079.63	80,211.79	80,277.96
0.8000	80,274.70	80,166.63	80,220.60	80,328.84	80,382.91
0.7000	80,367.83	80,269.05	80,318.43	80,417.26	80,466.72
0.5000	80,522.04	76,416.02	78,442.13	82,657.11	84,848.69
0.3000	94,399.85	85,088.27	89,623.16	99,431.13	104,730.45
0.2000	103,931.00	90,291.52	96,871.50	111,504.95	119,630.85
0.1000	126,794.05	104,128.59	114,903.88	139,914.61	154,393.05
0.0400	152,300.92	125,336.15	138,162.27	167,886.45	185,066.89
0.0200	185,727.03	144,546.31	163,847.88	210,527.78	238,640.00
0.0100	233,323.02	169,626.47	198,941.59	273,646.31	320,938.31
0.0040	290,191.16	197,270.25	239,261.53	351,961.72	426,880.91
0.0020	337,456.13	218,845.44	271,754.91	419,041.69	520,351.91
0.0010	388,765.59	241,144.58	306,184.28	493,620.00	626,755.50



	Exceedance Probability	Discharge (cfs)
1	0.50000	80522.00
2	0.20000	103931.00
3	0.10000	126794.00
4	0.04000	152301.00
5	0.02000	185727.00
6	0.01000	233323.00
7	0.00400	290191.00
8	0.00200	337456.00
9		

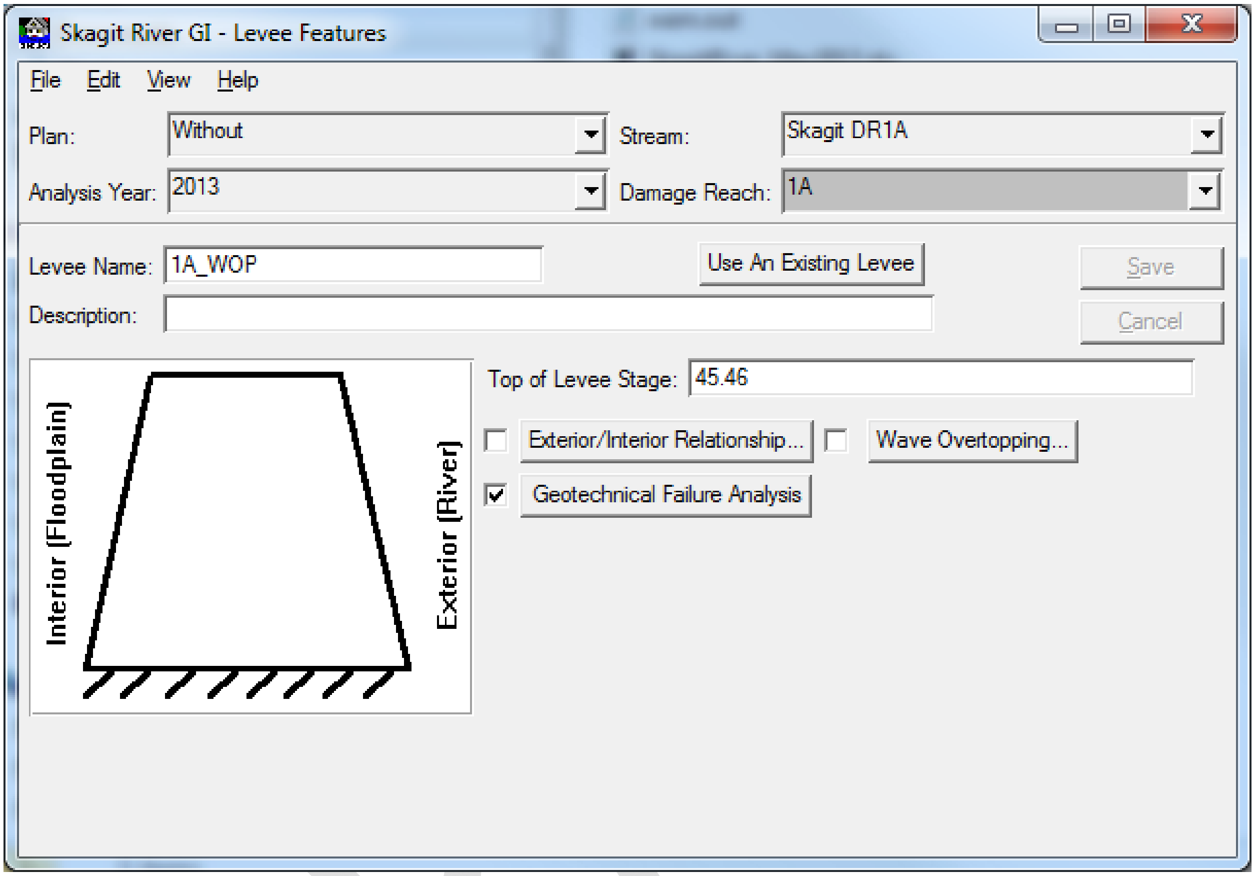


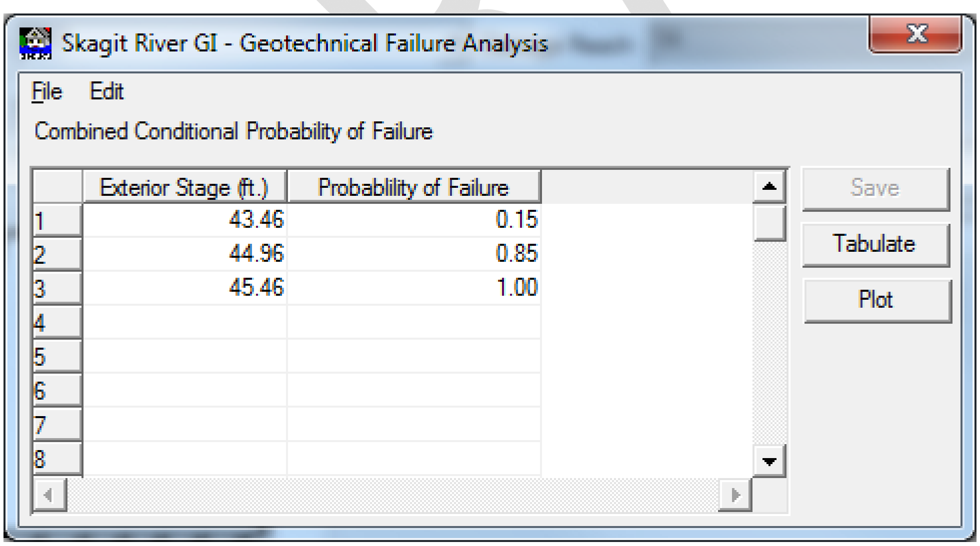
	Inflow (cfs)	Outflow (cfs)
1	80522.0	76409.0
2	103931.0	92639.0
3	126794.0	119121.0
4	152301.0	149531.0
5	185727.0	168378.0
6	233323.0	177981.0
7	290191.0	184410.0
8	337456.0	188547.0
9	501555.0	199539.0
10		



	Discharge (cfs)	Stage (ft.)	Standard Deviation of Error
1	0.00	6.47	0.000
2	76409.00	34.58	1.366
3	92639.00	37.17	1.491
4	119121.00	40.85	1.670
5	149531.00	44.47	1.846
6	168378.00	46.68	1.953
7	177981.00	47.64	2.000
8	184410.00	48.21	2.000
9	188547.00	48.55	2.000
10	199539.00	49.39	2.000
11			

Levee Inputs





List of Levees

File View Help

Skagit River GI
List of Levees

Name	Top of Levee Stage	Damage Reach Name	Stream Name
DR 4A Levee	33.30	4A	SkagitRiverDR4A
1A_WOP	45.46	1A	Skagit DR1A
2A_WOP	37.45	2A	Skagit DR2A
5_WOP	45.18	5	Skagit DR5
5A_WOP	45.18	5A	Skagit DR5A
6_WOP	40.00	6	Skagit DR6
6A_WOP	40.00	6A	Skagit DR6A
7_WOP	37.45	7	Skagit DR7
2_WOP	37.45	2	Skagit DR_2
3_WOP	27.50	3	Skagit River NF
4_WOP	16.74	4	Skagit River SF
1_WOP	48.66	1	Skagit-Dam_Rch_1

Attachment – Agriculture Supplemental Information

Flood Plain Agricultural Acreage

Event	Harvested Acres By Reach							
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Total
10-yr	2789	4146	0	0	0	0	198	7133
25-yr	5345	4794	0	108	0	31	906	11184
50-yr	16494	7796	0	645	0	243	997	26176
75-yr	18191	8183	0	4623	389	3521	1030	35937
100-yr	18891	8271	0	5531	398	3899	1051	38041
250-yr	22242	10874	0	5542	398	3899	1164	44119
500-yr	24140	10949	6734	5594	398	3904	1185	52904

Typical Farm Budget Example

Farm budgets were obtained from the Cooperative Extension, Washington State University. The Seattle Corps developed the monthly probability of flood occurrence, shown in the table below.

Monthly Flood Occurrence Probabilities

Month	Probability
January	21%
February	8%
March	4%
April	0%
May	0%
June	0%
July	0%
August	0%
September	0%
October	24%
November	22%
December	25%

The typical farm budget analysis employed for this analysis is shown in the table for winter wheat. The calculation of the potential damage inundation will cause to winter wheat is shown in the second table. The estimated effect of flood inundation for winter wheat, as well as for all other crops, is a 100 percent crop loss for all floods. This damage potential is based on the duration of flooding, from 2 to 5 days for all floods, flood depths, and the seasonal time of flooding and its effects on post-flood ground saturation duration.

Farm Budget Winter Wheat

OPERATION	MONTH	YR	TOT COST
Spray	oct	2002	$1.08
Fertilize	oct	2002	$45.79
haul seed	oct	2002	$1.17
Seed	oct	2002	$26.96
spray herbicide	apr	2003	$25.89
crop insurance	may	2003	$3.60
Spray	jul	2003	$0.67
Harvest	aug	2003	$20.86
haul wheat	aug	2003	$2.34
haul wheat	aug	2003	$3.24
misc use 2ton truck	ann	2003	$0.77
msic use tandem axle truck	ann	2003	$1.06
misc use tractor	ann	2003	$1.59
misc use 3/4ton truck	ann	2003	$6.41
misd use atv	ann	2003	$0.90
Overhead	ann	2003	$6.03
TOTAL PER ACRE			$148.36

Winter Wheat Weighted Loss Calculation

WINTER WHEAT WEIGHTED LOSS												
Yield per Acre	75 BU											
Price per BU	$4.55											
Gross Income	$341.25											
Total Production Cost	$148.36											
Net Income	$192.89											
Flood Weights	0	0	0.24	0.22	0.25	0.21	0.08	0.04	0	0	0	0
Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Variable Cost			48.04	0	0	0	0	0	25.89	3.6	0	0.67
Harvest	26.44											
Income	341.25											
Fixed Costs		16.76										
Monthly Net Cost Exposure			-64.80	-64.80	-64.80	-64.80	-64.80	-64.80	-90.69	-94.29	-94.29	-94.96
Monthly NI Expo-sure			192.89	192.89	192.89	192.89	192.89	192.89	192.89	192.89	192.89	192.89
Monthly Weighted DPI Loss			-15.55	-14.26	-16.20	-13.61	-5.18	-2.59	0.00	0.00	0.00	0.00
Monthly NI Loss Potential			46.29	42.44	48.22	40.51	15.43	7.72	0.00	0.00	0.00	0.00
Total DPI Loss	-67.39											
Total NI Loss	-200.61											
Total Flood Loss per Acre	-268.00											

Tulip Production

The flower industry in the Skagit Valley has become an important element of the county's economy[2]. Today, the Washington Bulb Company (WBC), Inc. has grown to be the largest tulip-bulb grower in the country and one of the largest employers in the Skagit Valley. The WBC has over 1,200 acres in bulb production with annual sales of over 50 million cut flowers and 10's of millions of bulbs shipped throughout the U.S. and Canada. The value of plant stock per acre is estimated at $18,000, according to WBC. In addition, WBC reports that each acre requires an additional $3,500 for land and soil preparation. Past floods to WBC production fields have resulted in the total loss of the plant stock. WBC indicated that based on previous flood experiences, and the expected duration and timing of study floods, a total loss of plant stock would most likely occur.

Data collected for this category will facilitate estimation of agricultural damages from flooding. NED benefits may be claimed when a reduction in flooding of agricultural land results in a reduction of crop loss. For basic crops (as defined by ER 1105-2-100 Appx E-20), data will be used to estimate the change in net income between with and the without project conditions. For other or non-basic crops efficiency benefits are assessed with the data.

Cropland

Data was collected from various agencies and educational institutions to characterize agriculture in the floodplain. The Washington State University Cooperative Agriculture Extension published reports were used to generally characterize crops in the floodplain. In addition, data on Skagit County was obtained from published reports from the 2007 USDA Census of Agriculture, including reported farmed acres by crop. Crop production budgets were obtained from Washington State University and University of California. Precedence was given to budgets nearest the study area. All budgets were updated to FY2009 price levels per ER1105-2-100.

Data indicated that the most prevalent crops in the County were alfalfa hay, potatoes, peas, winter wheat, and cucumbers, respectively. These crops constitute over 80% of the total farmed acres in the County. It is recommended that these crops be used to construct a composite crop to be used in modeling of damages. Crop budgets for each of the above five crops are included in the accompanying excel workbook. These budgets facilitate calculation of value at risk, by month, for each crop. This data can be used in conjunction with monthly probability of flooding to determine expected losses per acre should a field of a given crop flood. Use of a composite crop allows all agricultural acres in the floodplain to use the same damage function.

Washington Bulb Company

Data was obtained through direct coordination with the Washington Bulb Company. Skagit County provided a contact at the company who was able to characterize production characteristics and potential

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[2] Tulip damages have been restricted to WBC lands due to the denial of information from other growers. With WBC accounting for approximately 75% of all bulb lands the omission of the other growers only slightly underestimates the damage to bulb production.

flood damages to the facility. The following bullets summarize the data obtained. This data facilitates estimation of flood damages to the Washington Bulb Company.

- Bulk of business is the production of cut flowers for sale. Also bulb production.
- Over 200 million bulbs are in operation throughout the year
- In the event of a flood, bulbs are essentially destroyed
- The normal purchase price for replacement bulbs is $0.13 per bulb, but it is difficult to purchase quantities exceeding 1 million bulbs at once. In addition, prices would be much higher in an emergency situation.
- The planting period is September through November, with harvest in late spring or early summer
- Approximately $4,000 of pre-planting work must be completed per acre, immediately
- following the prior season's harvest
- If fields are flooded, crop is lost
- 350-400 acres of tulips are farmed. 175 acres of iris are farmed
- 240,000 per acre yield for tulip and iris
- 500 acres of daffodil are farmed
- 60,000 per acre for daffodil
- There are 15 acres of greenhouses, 15 acres other miscellaneous structure
- Value of structures and contents, excluding bulbs, about $50 million
- Other structures are of steel pole type construction
- Annual sales total about $25 million; breakdown is
- $22.5 million in cut flowers sales; this is 80 million flowers
- 45 million flowers from the greenhouses
- 35 million flowers from the fields
- $2 million bulbs sales
- Infrastructure at risk includes high tech computer-operated facilities that rely on climate control systems.
- Power outage would cause major problems to operation of bulb coolers. Loss of bulbs would occur in about 3 days.

Data sources:

- Washington State University Cooperative Extension, 2009

- Washington State University, School of Economic Sciences, Farm Management, 2009
- U.S. Department of Agriculture, Census of Agriculture 2007
- University of California, Agriculture and Natural Resources Extension, 2009
- Coordination with Washington Bulb Co via Skagit County