Illabot Creek Habitat Restoration Feasibility Study

*** FINAL DRAFT FOR REVIEW ***

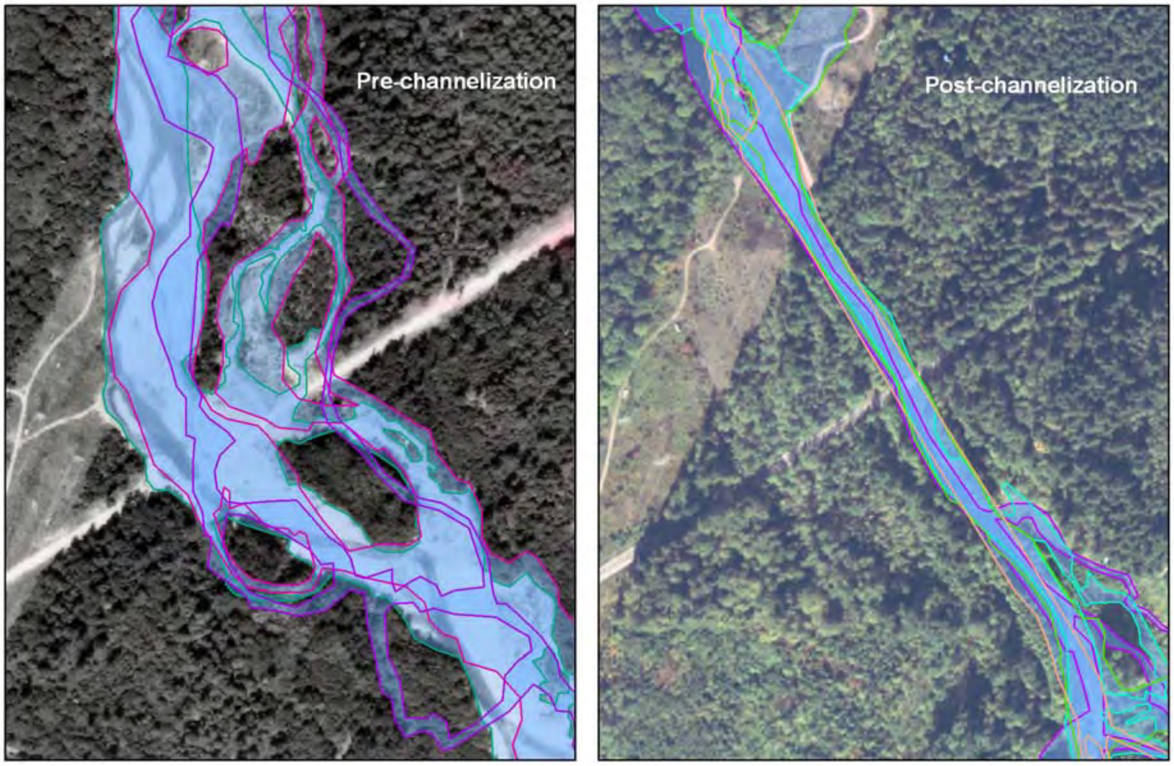

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

Illabot Creek is a very productive tributary of the Skagit River that supports populations of Chinook, chum, coho, and pink salmon, native char and steelhead trout. Much of the watershed has already been protected or restored. However, there are a number of habitat impacts in the floodplain and alluvial fan reach that are limiting the full fish production potential. The purpose of this feasibility study is to evaluate present habitat conditions, identify specific habitat impacts on the floodplain or alluvial fan of Illabot Creek, and develop and evaluate habitat restoration projects that could address those impacts. This report includes general information about the Illabot Creek watershed and the fish use in the area, a review of historic channel conditions from aerial photographs, a characterization of current habitat conditions, and a detailed assessment of habitat impacts caused by sediment, riparian vegetation, fish passage, and hydromodification. The final section presents alternatives for addressing each of the impacts identified.

2 WATERSHED DESCRIPTION

2.1 GEOGRAPHY

Illabot Creek is a medium-sized tributary entering on the left bank of the Skagit River shortly upstream from the town of Rockport at approximately River Mile 71.8 (River KM 115.6) (Figure 2-1). It drains a watershed approximately 48 square miles (124.3 km^2) in area and has elevations ranging from 80 m (262 ft) in the lower reaches along the Skagit River floodplain to over 2,000 m (6562 ft) on some of the tallest peaks. Most of the watershed drains steep, mountainous terrain in the North Cascades, with approximately 26% of the watershed between 500-1000 m and approximately 59% over 1,000 m. Elevations and stream gradients are lowest in the lower 7 kilometers of Illabot Creek where the stream emerges from a confined valley in mountainous terrain, deposits sediment on an alluvial fan and runs through the relatively flat terraces and floodplain of the Skagit River. It is in these lower reaches where fish production is the highest and where some habitat impacts remain, so this area is therefore the focus of this feasibility study.

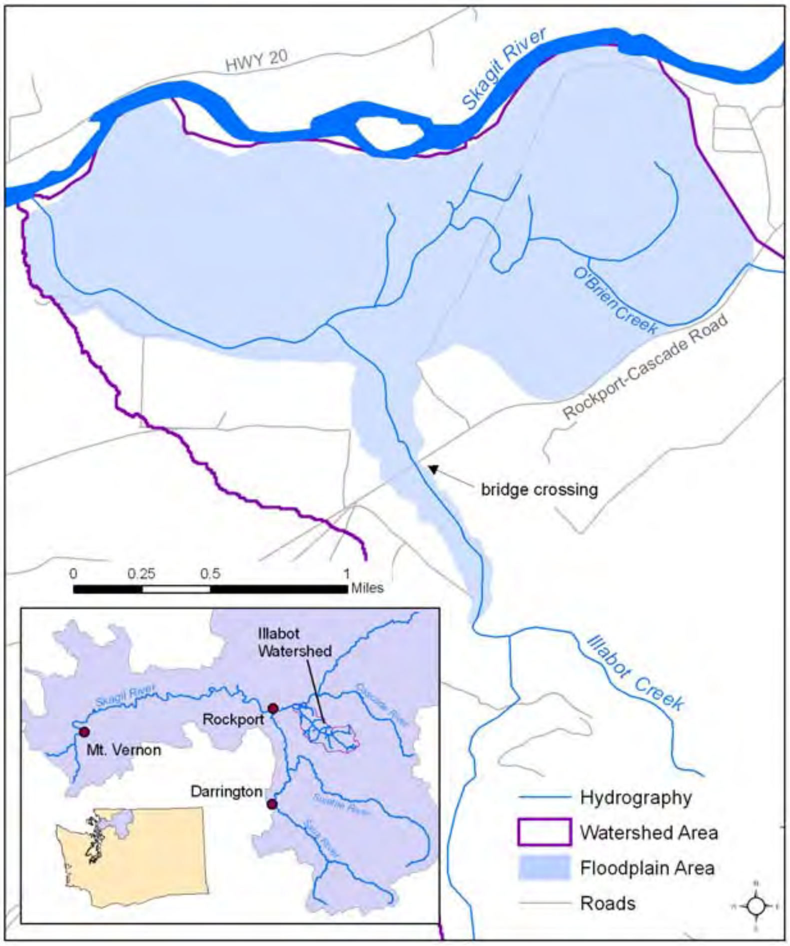


Figure 2-1. Location map for Illabot Creek

Average annual precipitation in the Illabot watershed is approximately 95 inches, with a range between 65 inches in the lower watershed and 119 inches on some of the higher peaks. The majority of precipitation falls during fall, winter, and early spring months, and during the winter much of it falls as snow above 1,000 m. Stream flows are generally lowest in the late summer, when the winter snowpack has melted and rainfall is limited. Stream flows can also be low in the winter months during periods of cold temperatures and/or limited precipitation. Higher flows occur following rainstorms during the fall and winter and during rainstorms and snowmelt during the spring months. Peak flows generally occur following intense rainstorms in the fall and winter, with the largest peaks resulting from rain-on-snow events caused by precipitation at rapidly increasing or relatively high freezing levels following a period of snow accumulation at lower elevations.

2.2 FLOW REGIME

Illabot Creek does not have a stream gage, but peak stream flows were estimated using drainage area and mean annual precipitation with regression equations from Sumioka et al. (1998). The equations were developed for several regions in western Washington using regression equations from 527 unregulated stream gages with more than 10 years of record.

$Q=aA^bP^c$

A = watershed area in miles
P = mean annual precipitation in inches
a,b,c = constants based on region and peak flow recurrence interval

In order to use this equation, the Illabot Creek watershed boundary was delineated using 10-m DEMs from a location approximately 3,000 ft downstream of the bridge over Illabot Creek on Rockport-Cascade Road. Mean annual precipitation was calculated by using a weighted-area average of annual precipitation estimates from the PRISM model for the watershed. Results are presented in Table 2-1.

Recurrence interval	**a**	**b**	**c**	**Area (mi^2)**	**Mean Annual Precip (in)**	**Estimated discharge (cfs)**
2-yr				43	94.9	
10-yr	0.129	0.868	1.57	43	94.9	4,294
100-yr	0.174	0.861	1.62	43	94.9	7,083

Table 2-1. Peak flow estimates for Illabot Creek using equations from Sumioka et al. (1998).

There are two nearby unregulated gages that can be used to determine when large peak flows may have occurred in Illabot Creek. These gages are in a similar hydrologic region draining watersheds with similar basin elevation as Illabot Creek, but both have greater mean annual precipitation and the Newhalem gage has a smaller drainage area, while the Sauk gage has a larger drainage area.

Station Name	**USGS Station Number**	**Drainage Area (mi2)**	**Elevation (ft)**	**Mean Annual Precip (in)**	**10-yr peak flow**	**100-yr peak flow**
Sauk River above Whitechuck River	12186000	152	3,700	139	19,500	39,100
Newhalem Creek nr Newhalem, WA	12178100	27.9	4,140	125	4,310	8,560

Table 2-2. Characteristics of two stream flow gages near Illabot Creek, from Sumioka et al. (1998)

The history of peak flows in these two drainages can be used to develop an idea of when Illabot Creek experienced larger peak flows (Table 2-3). Peak flows with a 10-year recurrence interval or greater likely occurred in water years 1918, 1922, 1932, 1934, 1950, 1951, 1963, 1976, 1980, 1981, 1991, 1996, 2004. Peak flows with a 25-year recurrence interval or greater likely occurred in water years 1922, 1950, 1981, and 2004. Note that precipitation intensity can be highly variable across the landscape, so without accurate flow records it is impossible to know the exact magnitude of peak flows on Illabot Creek. For example, the flood in October 2003 was estimated at over a 100-yr flow event on the Sauk River, but less than a 10-yr event on Newhalem Creek and the two floods in November 1990 and November 1995 were estimated at less than 25-yr events on both gages but were considerably larger in other parts of the Skagit basin.

	Sauk River above Whitechuck			**Newhalem Creek nr Newhalem**		
Water Year*	**Date**	**peak flow (cfs)**	**approx. recurrence interval (yr)**	**Date**	**peak flow (cfs)**	**approx. recurrence interval (yr)**
1918	29-Dec-17	24,400	17			
1919	14-Dec-18	8,430	2			
1920	15-Nov-19	11,400	3			
1921	4-Oct-20	8,960	2			
1922	12-Dec-21	29,100	31			
1929	9-Oct-28	7,030	2			
1930	5-Feb-30	5,060	1			
1931	27-Jan-31	7,410	2			
1932	26-Feb-32	22,900	14			
1933	13-Nov-32	13,000	4			
1934	21-Dec-33	18,600	8			
1935	25-Jan-35	13,200	4			
1936	16-May-36	4,400	1			
1937	3-Jun-37	4,310	1			
1938	18-Apr-38	8,240	2			
1939	29-May-39	7,010	2			
1940	15-Dec-39	5,480	1			
1941	18-Oct-40	4,180	1			
1942	2-Dec-41	7,220	2			
1943	23-Nov-42	6,230	2			

1944	3-Dec-43	10,300	3			
1945	7-Feb-45	8,940	2			
1946	25-Oct-45	8,950	2			
1947	25-Oct-46	10,200	3			
1948	19-Oct-47	13,500	4			
1949	13-May-49	5,660	1			
1950	27-Nov-49	30,200	36			
1951	10-Feb-51	20,800	10			
1952	5-Jun-52	5,080	1			
1953	31-Jan-53	9,360	2			
1954	31-Oct-53	5,600	1			
1955	10-Jun-55	6,460	2			
1956	4-Nov-55	14,400	4			
1957	10-Dec-56	9,650	2			
1958	26-May-58	4,440	1			
1959	20-Nov-58	11,200	3			
1960	15-Dec-59	14,700	5			
1961	15-Jan-61	9,730	2	17-Jun-61	975	1
1962	3-Jan-62	7,250	2	3-Jan-62	1,230	1
1963	20-Nov-62	13,800	4	20-Nov-62	5,600	19
1964	1-Jan-64	6,610	2	30-Sep-64	1,700	2
1965	30-Nov-64	6,880	2	2-Oct-64	855	1
1966	6-May-66	4,890	1	6-Oct-65	1,350	2
1967	13-Dec-66	7,410	2	16-Dec-66	2,260	3
1968	27-Oct-67	16,800	6	27-Oct-67	2,950	4
1969	5-Jan-69	6,010	1	5-Jan-69	1,570	2
1970	3-Jun-70	4,970	1	3-Jun-70	958	1
1971	19-Jan-71	7,180	2	23-Nov-70	1,270	1
1972	28-Feb-72	7,820	2	12-Jul-72	2,400	3
1973	26-Dec-72	5,910	1	19-Dec-72	1,020	1
1974	16-Jan-74	12,500	3	16-Jan-74	1,740	2
1975	21-Dec-74	8,670	2	21-Dec-74	1,520	2
1976	4-Dec-75	19,400	9	4-Dec-75	3,470	5
1977	18-Jan-77	8,610	2	18-Jan-77	2,920	4
1978	1-Nov-77	12,900	4	25-Nov-77	2,240	3
1979	4-Nov-78	7,480	2	7-Nov-78	2,920	4
1980	18-Dec-79	19,000	8	18-Dec-79	4,400	9
1981	26-Dec-80	40,100	134	26-Dec-80	8,430	106
1982	15-Feb-82	7,240	2	13-Aug-82	1,020	1
1983	3-Dec-82	17,300	7	3-Dec-82	2,960	4
1984	4-Jan-84	12,600	4	4-Jan-84	4,210	8
1985	7-Jun-85	6,470	2	7-Jun-85	1,320	2
1986	19-Jan-86	12,900	4	18-Jan-86	2,790	4
1987	23-Nov-86	11,800	3	23-Nov-86	2,240	3
1988	9-Dec-87	6,840	2	25-Sep-88	1,080	1
1989	16-Oct-88	10,500	3	5-Nov-88	2,530	3
1990	4-Dec-89	16,000	6	4-Dec-89	3,630	6
1991	24-Nov-90	24,600	17	10-Nov-90	2,870	4
1992	5-Dec-91	5,970	1	11-Nov-91	1,840	2
1993	12-May-93	5,140	1	12-May-93	935	1
1994	2-Mar-94	4,690	1	23-Oct-93	941	1
1995	19-Feb-95	8,390	2	1-Feb-95	1,400	2
1996	8-Nov-95	24,100	16	29-Nov-95	4,500	10
1997	19-Mar-97	10,100	3	9-Jul-97	1,680	2
1998	30-Oct-97	13,800	4	30-Oct-97	2,020	2
1999	29-Dec-98	7,780	2	13-Dec-98	1,310	1

2000		12-Nov-99	13,000	4		12-Nov-99	2,560	3
2001		23-May-01	3,670	1		23-May-01	807	1
2002		7-Jan-02	13,500	4		7-Jan-02	2,580	3
2003		26-Jan-03	10,800	3		26-Jan-03	1,579	2
2004		20-Oct-03	44,000	225		20-Oct-03	4,100	8

***** Water years extend from October 1st of the previous year to September 30th of the water year

Table 2-3. Annual peak flows from USGS web site (http://nwis.waterdata.usgs.gov/wa/nwis/peak). Peak flow recurrence intervals were estimated using regression equations developed from the weighted exceedence probability values reported for these gages in Sumioka et al. (1998).

2.3 FISH USE

Illabot Creek is a highly productive stream that has six anadromous fish species: Chinook, chum, coho, and pink salmon, native char, and steelhead trout. Sockeye salmon have also been occasionally observed in Illabot Creek, although not in significant numbers. Chinook salmon and native char are listed as threatened under the Endangered Species Act, and the stocks of Chinook and steelhead present in Illabot Creek are listed as "Depressed" in the Salmonid Stock Inventory (WDFW and WWTIT 2002).

The Washington Conservation Commission mapped the distribution of each of these fish species as part of a habitat limiting factors analysis for the Skagit River basin (Smith 2003). These maps were developed from interviews and meetings with regional field biologists to document where fish of each species had been observed. The results of this effort and more recent information from WDFW field biologists (Brett Barkdull, personal communication) were used to map the distribution of fish in the Illabot Creek watershed (Figure 2-2 and Figure 2-3). It is important to note that while this information is useful for identifying where fish are generally present, it is not exhaustive. There are likely some habitats and locations where fish are present at least some of the time that were not mapped as part of this process because they were not observed or reported by a field biologist.

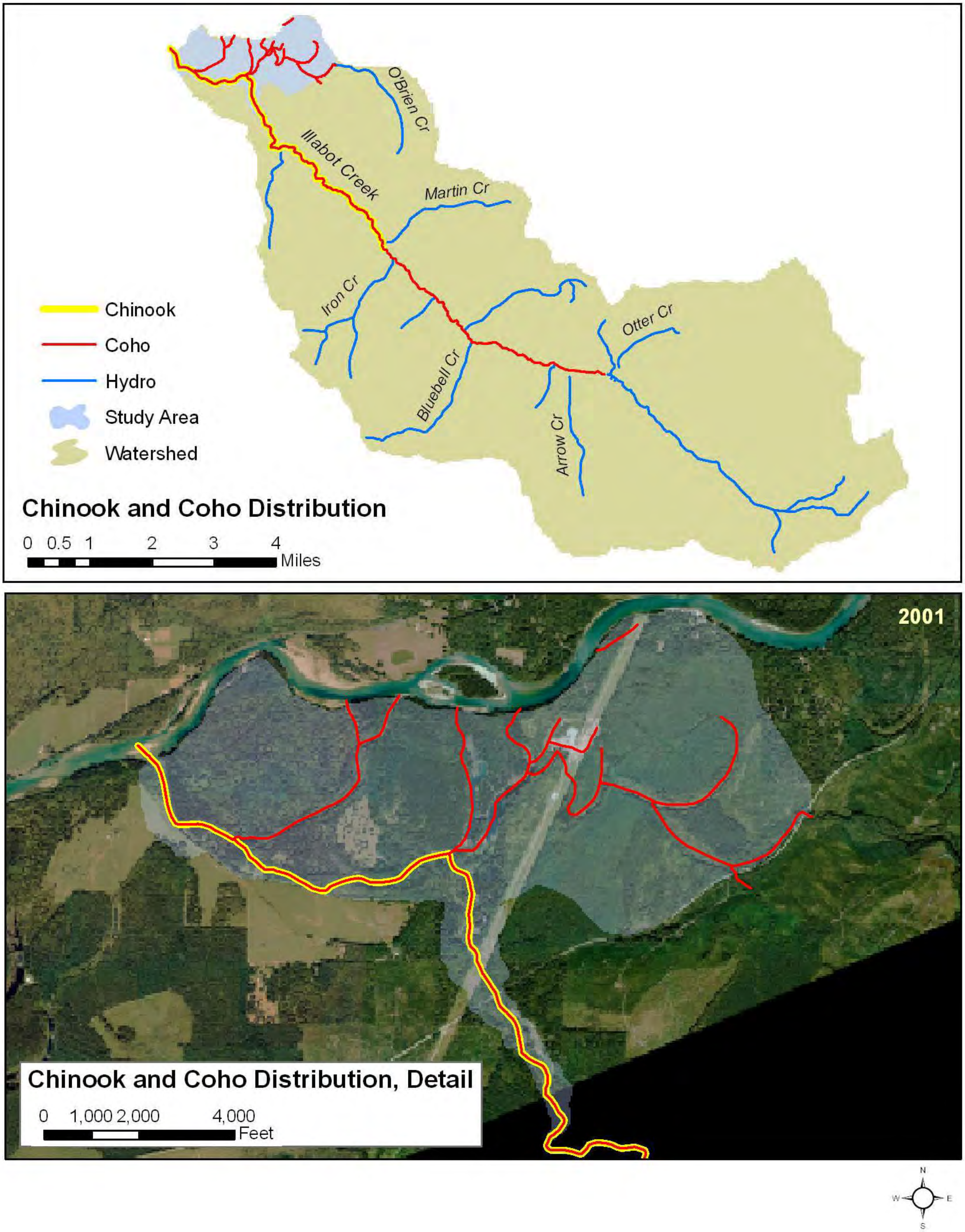


Figure 2-2 Coho and Chinook Distribution in Illabot Creek

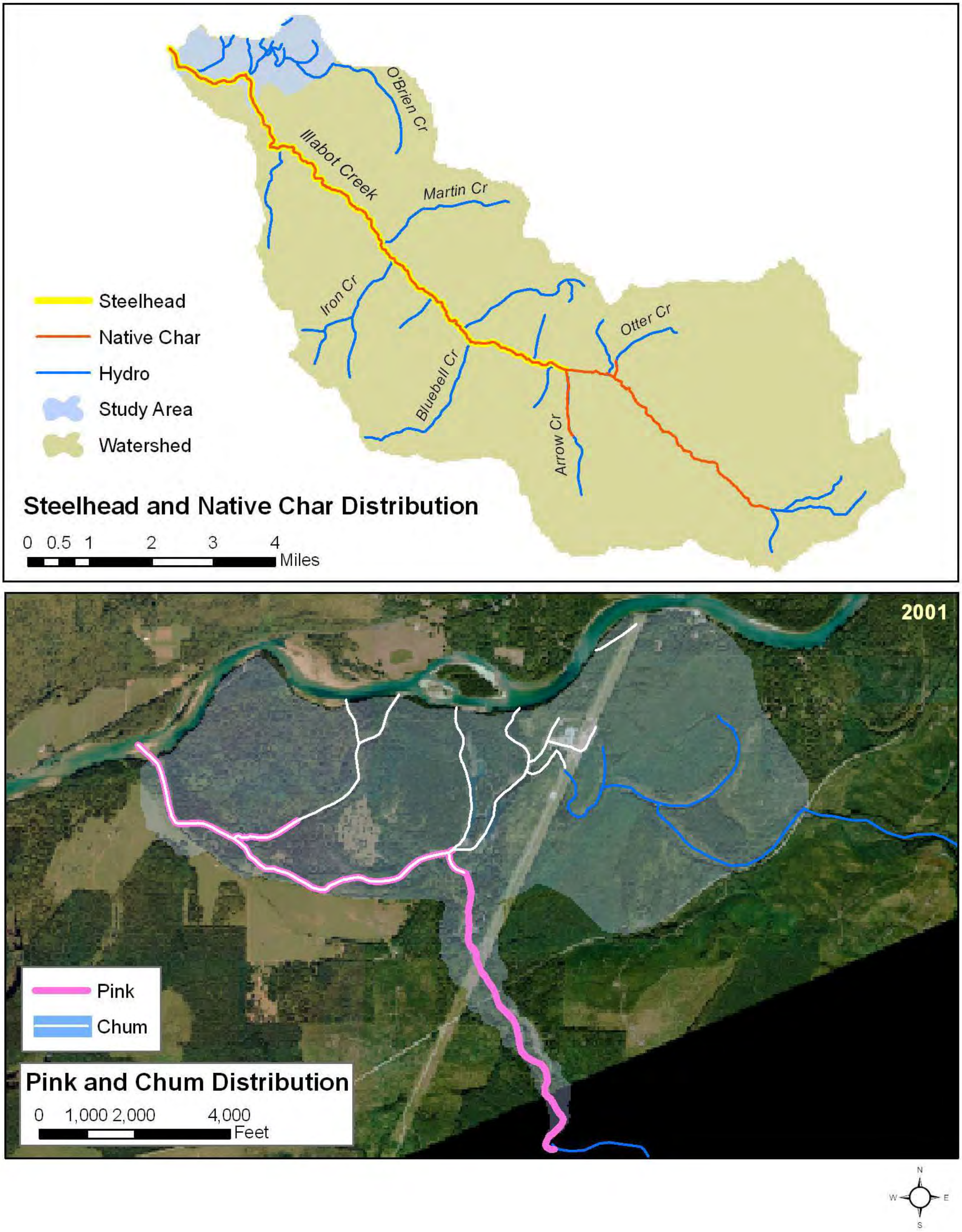


Figure 2-3 Steelhead, Native Char, Pink, and Chum Distribution in Illabot Creek

The reach of Illabot Creek extending from the Rockport-Cascade Road bridge downstream to the mouth has been a WDFW spawning survey index reach for Chinook salmon since 1974, pink salmon since 1959, and chum salmon since 1968. The reach has generally been considered to be 1.9 miles long for spawning density estimates, although the actual length surveyed in any given year varies due to changes in the channel. Figure 2-4 shows the escapement estimates for Chinook in the Illabot index reach based on spawning redd counts from WDFW spawning survey records for the years 1991-2005 (data provided by Brett Barkdull, WDFW). Escapement refers to the number of fish that successfully return to their spawning areas during a single spawning season. The Chinook in Illabot Creek are part of the "Upper Skagit Mainstem/Tribs" stock, so the figure also shows total escapement estimates for the entire stock for comparison purposes (WDFW and WWTIT 2002; data for additional years provided by Brett Barkdull, WDFW and Rebecca Bernard, SRSC). This stock spawns in September and October in the mainstem Skagit River and large tributaries upstream from the confluence with the Sauk River to the town of Newhalem (not including the upper Cascade River), and represents the majority of Chinook that spawn in the Skagit River basin. During this time, 0 to 830 spawners/year have been estimated for the index reach with an average of 176 spawners/year. On any given year, the index reach accounted for 0 – 11% of the total escapement for the stock, with an average of 2.3%. Clearly, Illabot Creek is an important contributor to Chinook production in the Skagit River basin.

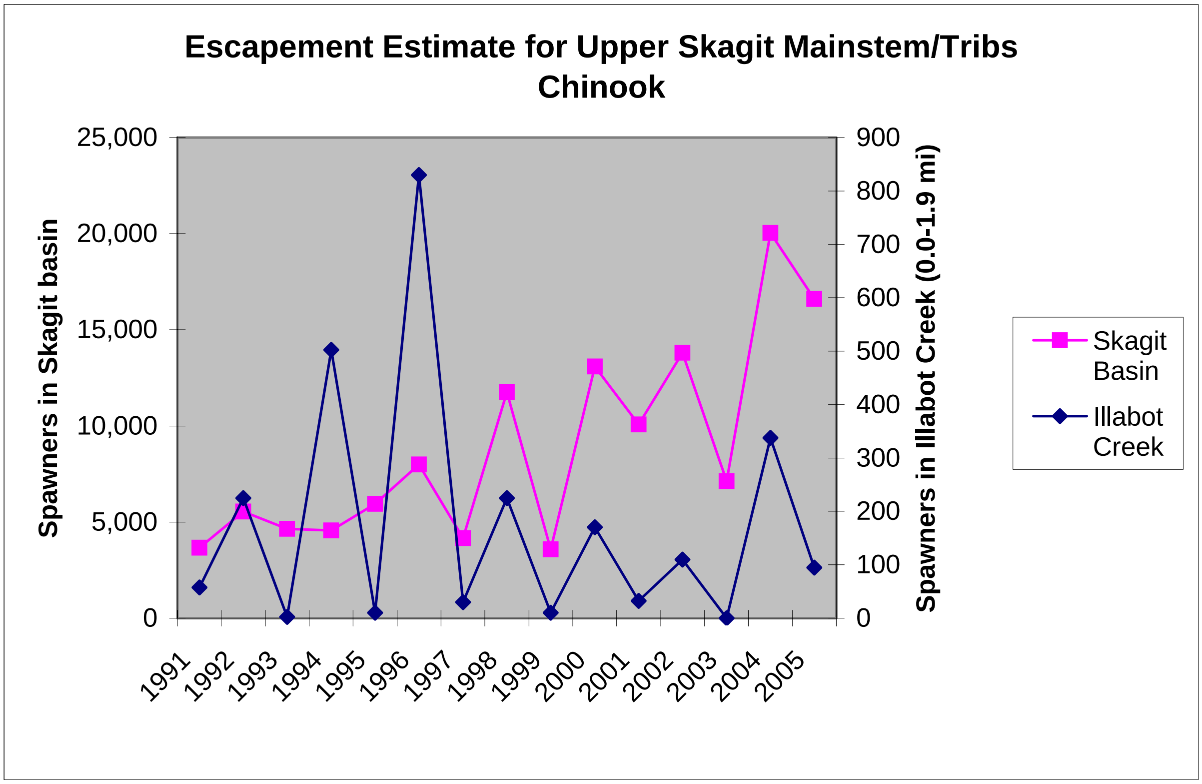


Figure 2-4. Escapement estimates for Chinook salmon in Illabot Creek compared to estimates for Skagit basin.

Figure 2-5 shows the escapement estimates for pink salmon in the 1.9-mile index reach based on observed live fish from the WDFW spawning survey records for the years 1959-2005 (Brett Barkdull, WDFW, unpublished data). The pink salmon in Illabot Creek are part of the “Skagit Pink” stock so the figure also shows total escapement estimates for the entire stock from 1967-2005 for comparison purposes (WDFW and WWTIT 2002; Brett Barkdull, WDFW and Rebecca Bernard, SRSC, unpublished data). This stock spawns during odd-numbered years in late August through October in the mainstem Skagit and Sauk Rivers and numerous tributaries. This is the only pink salmon stock in the Skagit basin, so these numbers represent the entire Skagit River pink salmon escapement. During this time, 825 to 77,689 spawners/year were estimated for the index reach with an average of 11,416 spawners/year. On any given year, the index reach accounted for 1 – 14% of the total escapement for the stock, with an average of 4%. Even more than for Chinook salmon, Illabot Creek is an important contributor to pink salmon production in the Skagit River basin.

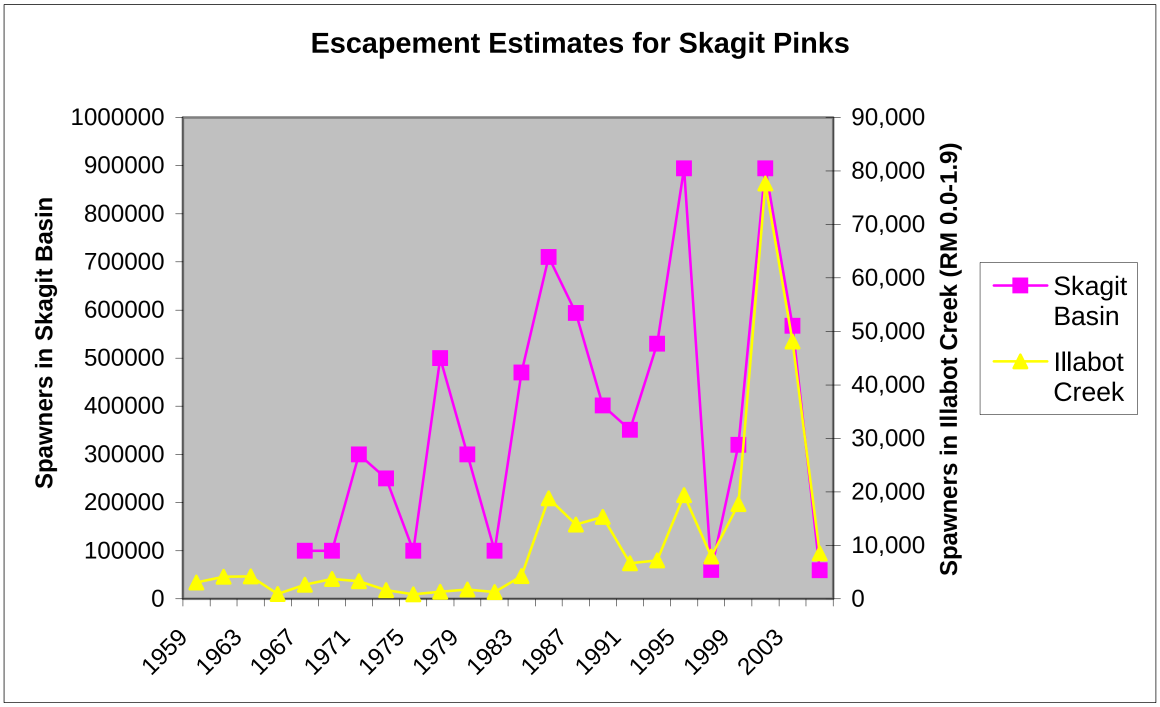


Figure 2-5. Escapement estimates for pink salmon in Illabot Creek compared to estimates for Skagit basin.

Although no survey records exist for spawners from other species, habitat inventories and observations of fish biologists suggest that Illabot Creek is highly productive for other fish species as well. In particular, WDFW suveys have documented extensive chum salmon spawning in the lower reaches of Illabot Creek and associated floodplain channels (Brett Barkdull, personal communication), and Beamer et al. (1998) documented an abundance of coho winter and summer rearing habitat in the lower 7 kilometers of Illabot Creek and associated floodplain channels.

2.4 LAND OWNERSHIP AND LAND USE

Land ownership and land use in the Illabot Creek watershed includes private, state, and federal ownership with land uses including a few recreational cabins and homes, agriculture, conservation, and forestry. Table 2-4 and the following maps describe land ownership and use for the watershed as a whole. This information comes from Skagit County parcel layer and assessor's data, 2005.

Land Uses	**Owner**	**Acres**	**% of Watershed**
Agriculture	Private	200	0.7
Conservation	SCL	2,630	8.5
	TNC	298	1.0
	WDFW	184	0.6
Conservation Total		*3,112*	*10.1*
Federal Timber	USFS	13,716	44.6
Home/Vacation/Cabin	Private	62	0.2
State and Private Timber	Cascade Timberlands	617	2.0
	DNR	1,483	4.8
	Private	207	0.7
State and Private Timber Total		*2,307*	*7.5*
Wilderness Area	USFS	11,112	36.1
Other	Other	163	0.5
Unknown	Unknown	105	0.3
Total Acres		*30,777*	

Table 2-4. Summary of land ownership and land use in the Illabot Creek watershed

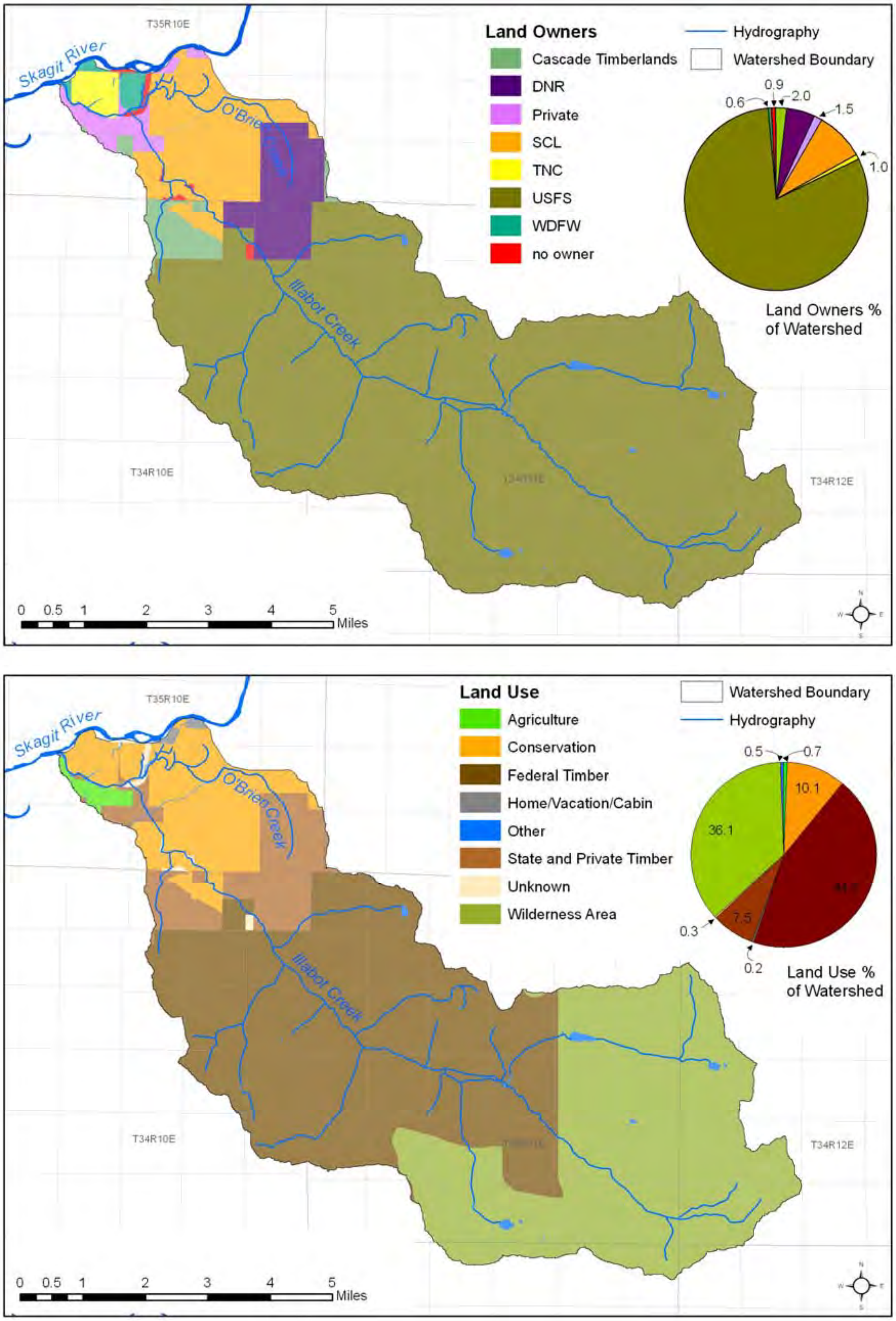


Figure 2-6 Land ownership and land use in the Illabot Creek watershed

2.5 PAST HABITAT RESTORATION PROJECTS

Due to its high value for fish production, Illabot Creek has been the focus of a wide variety of habitat restoration and protection efforts over the years. Efforts have included sediment reduction treatments on forest roads, construction of groundwater channels to enhance off-channel habitat, and land acquisition for conservation purposes. These are described in more detail below.

2.5.1 Forest Road Sediment Reduction

Road restoration in the Illabot Creek watershed has focused on reducing the input of sediment from forest roads through road upgrade, storage, and decommissioning projects. There are about 44 miles of road falling on private, state, and federal timber lands in the Illabot watershed, of which over 31 miles have been addressed in road treatment projects. In 1995, the United States Forest Service (USFS) storm-proofed 23.9 miles of Forest Road 16, 11.1 miles of which fall within the Illabot watershed (mileage based on GIS measurements). Upgrade treatments included replacing, upgrading, and maintaining culverts, constructing additional crossings, installing riprap, removing road fill, and reconditioning the road surface. Two spur roads were also treated at that time. Road 1600012 was upgraded along 0.2 miles and Road 1600012a, totaling 0.6 miles, was decommissioned. Decommissioning and storage treatments included removing fills and culverts, constructing dips to provide road drainage, pulling back sidecast material and outsloping the road (Beamer et al.1998). In 1999, the USFS completed an additional treatment on FR16 that included 2.9 mi of storage and 3.2 mi of upgrade. The USFS also treated FR1620 in 1999, upgrading 0.4 mi and storing 2.4 mi of road within the Illabot watershed. In total, the USFS has treated 20.7 miles of road within the Illabot watershed: upgrade = 14.8 mi, storage = 5.3 mi, decommission = 0.6 mi. Approximately 3.8 mi of road falling under USFS ownership has received no treatment.

In 2005, Seattle City Light (SCL) decommissioned approximately 18.7 miles of forest road on SCL-owned property, approximately 13 miles of which fall within the Illabot and O'Brien watersheds (measurement from GIS). Storage work included removing culverts and fill, constructing waterbars, pulling back sidecast material, insloping roads, and blocking road access. An additional 3 roads totaling 2.2 miles within SCL ownership on the Illabot alluvial fan have been blocked to vehicle access and are considered low to no risk for sediment delivery but have not been officially abandoned. Approximately 1 mi of road remains untreated on SCL property, spurs off the mainline that is shared with Cascade Timberlands.

The Department of Natural Resources owns 0.83 mi of road within the Illabot watershed, all of which have been addressed by RMAPs. Seattle City Light provided abandonment work in 2005 for 0.3 mi of road adjacent to their property, and the remainder are considered orphaned roads. Orphaned roads are roads that have not been used after 1974 and are not required to be treated.

Cascade Timberlands owns approximately 537.5 acres in the Illabot watershed, purchased in 2004 from Crown Pacific LTD. Before the ownership transfer, Crown Pacific did not submit a Road Maintenance and Abandonment Plan (RMAP) for its Illabot road block. Cascade Timberlands submitted an RMAP plan in November of 2005; however the entire block owned by Cascade Timberlands is for sale again and the new owners will have comply with an approved RMAP. Approximately 8.4 miles of road fall under the owner's maintenance responsibilities, of which Cascade Timberlands identified 2.3 miles of road for abandonment and 6.1 miles for improvement or routine maintenance. About 2 miles of road are adjacent to Seattle City Light property.

An additional 6 miles of road within the Illabot watershed fall under private (private drives and residence access and SCL powerline right-of-way) or county (Rockport Cascade Road, Martin Ranch Road) ownership. Small forest owner Pauline Ryan abandoned, unofficially, 0.14 mi of road after harvesting timber on her land in summer 2005. The remaining roads do not fall within timber lands.

Owner	**Decommission /Storage**	**Upgrade**	**Access Blocked**	**Unknown/ No Work Done**	**Orphaned**	**Total**
USFS	0.5	14.8	0	3.8	0	*19.1*
Cascade Timberlands	0	0	0	8.4	0	*8.4*
DNR	0.3	0	0	0	0.5	*0.8*
Private Timber	0.1	0.4	0	0	0	*0.5*
SCL	12.9	0	2.2	0	0	*15.1*
Unknown	0	0	0	0.4	0	*0.4*
Total	*13.8*	*15.2*	*2.2*	*12.6*	*0.5*	*44.3*

Table 2-5 Summary of Road Treatments in the Illabot Creek Watershed

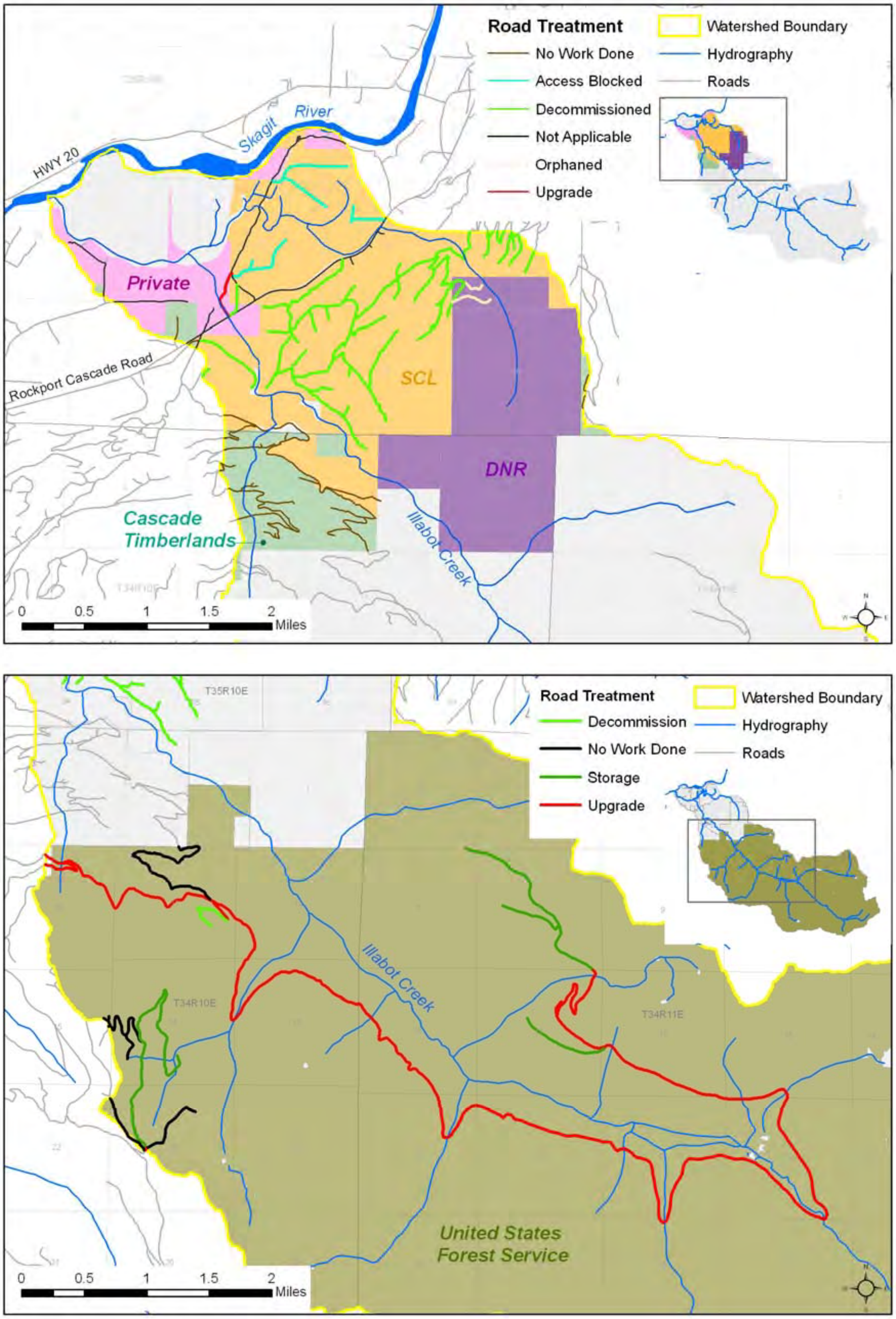


Figure 2-7 Road treatments in the Illabot Creek watershed

2.5.2 Off-channel Habitat Construction

In addition to sediment reduction projects, three off-channel habitat projects have been constructed by Washington Department of Fish and Wildlife (WDFW) and Seattle City Light in an effort to increase the amount of functioning off-channel habitat available for anadromous species, specifically chum salmon (Figure 2-8). Hydroelectric dams on the Upper Skagit River have impacted the natural processes that help to create off-channel habitat. A mitigation program, the Off-Channel Chum Habitat Development and Improvement Program (Chum Program), was created through the 1991 Skagit Settlement Agreement that provides funds to protect, restore, or construct off-channel habitats (Smith 2005). The three projects constructed in the Illabot watershed include:

1) Illabot Channel, an off-channel construction project, was completed in 1995. Illabot Channel is groundwater-fed and contains 1,672 ft^2 of habitat.

2) Illabot Channel Expansion, a constructed expansion of the existing Illabot Channel, was completed in 2001. The Illabot Channel Expansion contains 2,430 ft^2 of habitat.

3) Powerline Channel, an off-channel construction project, was completed in 2003. Powerline channel contains 7,600 ft^2 of habitat. Powerline channel is a constructed groundwater pond and outlet channel that connects to the Skagit River.

In addition to the constructed channels, WDFW enhanced O'Brien Creek in 1996 by placing spawning gravel downstream of the powerline corridor culvert to provide additional spawning habitat for chum salmon (Figure 2-8). Spawning gravel was placed in 20'x40' spawning pads for an approximate habitat area totaling 2400 ft^2. Several wood structures were also placed adjacent to the spawning pads to provide cover and to help stabilize the spawning gravel pads. Spawning gravel is still in place at this location; however, the undersized culvert at the powerline road crossing contributes to the problem of higher flow conditions that has in the past washed the rock downstream and into assorted piles.

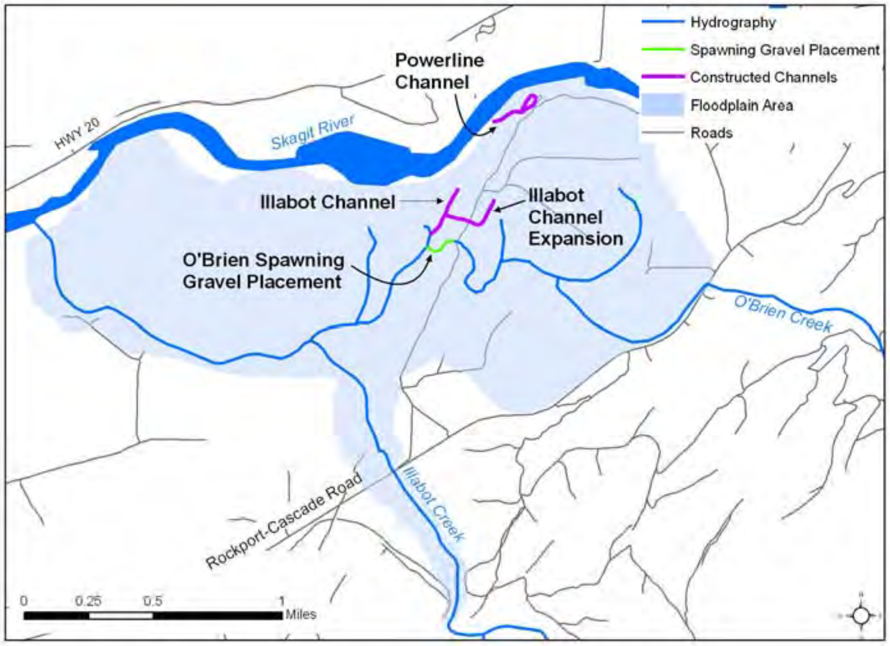


Figure 2-8 WDFW constructed channels and habitat structures on the Illabot Creek floodplain

2.5.3 Conservation Acquisition

In addition to active restoration, there has been a number of land acquisitions intended to protect existing high quality habitat. Over 3,000 acres of property have been acquired for the purposes of conservation in the Illabot Creek watershed (Table 2.6 and Figure 2.9). Approximately 1500 acres of land fall within the Skagit River flooplain associated with Illabot Creek. Protection of floodplain habitat has been prioritized in the Skagit River basin because of its importance in providing foraging and refugia for all freshwater life history phases of salmon (SRSC and WDFW 2005). Approximately 77% of the property within the floodplain associated with Illabot Creek has been purchased for conservation purposes by Seattle City Light, WDFW, and The Nature Conservancy. Other land uses in the Illabot/Skagit floodplain include agriculture, private residences, and state and private timber.

Land Uses	Owner	Total Acres	% of Floodplain Area
Agriculture	Private	34.0	2.3
Conservation	SCL	654.0	44.6
	TNC	297.9	20.3
	WDFW	184.3	12.6
Conservation Total		*1136.2*	*77.5*
Home/Vacation/Cabin	Private	60.6	4.1
Other	No Owner (road, water)	52.8	3.6
State and Private Timber	Private Timber	120.0	8.2
Unknown	Unknown	63.1	4.3
Total		*1466.6*	

Table 2-6 Land uses on the Illabot Creek floodplain

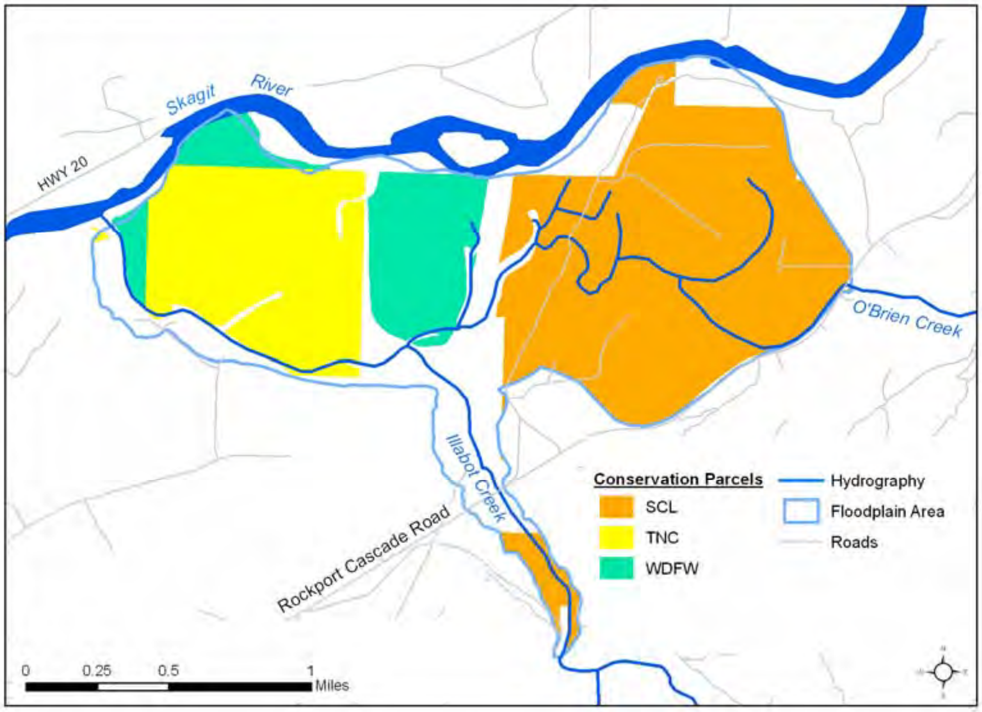


Figure 2-9 Conservation parcels within the Illabot Creek floodplain

3 HABITAT ASSESSMENT

3.1 HISTORIC CONDITIONS

Locations of historic channels were assessed using historic aerial photographs and topographic maps acquired from various sources. Aerial photographs were borrowed from the USFS air photo libraries at the Mt. Baker and Darrington Ranger Districts, and include projects flown by the USFS, Washington Department of Natural Resources, and Army Corps of Engineers. The coverage and scale of the photos varies among projects (Table 3-1). The photos were scanned with an Epson GT-10000 scanner and Epson Scan version 2.34 software at a resolution of 800 DPI and saved as tiffs. The air photos were imported into ArcGIS 8.3 and georeferenced to a 2001 orthophoto (source: Skagit County and Space Imaging) and projected into the NAD 1927 State Plane Washington North coordinate system.

Year	Scale	Color/BW	Photo producer	Comments
1943	1:20000	bw	War Department, Army Corps of Engineers	missing western portion of Illabot alluvial fan, including mouth of creek
1944	1:20000	bw	U.S. Army Air Corps	study area mostly complete -- misses very upstream portion of Illabot; scanned (600 dpi) and georeferenced by Collins and Sheikh 2002
1956	1:15840	bw	USDA Forest Service	missing northeastern of alluvial fan, including inlet of side channel
1963	1:12000	bw	USDA Forest Service	study area complete
1972	1:15840	color	USDA Forest Service	study area complete
1979	1:24000	color	USDA Forest Service	study area complete
1983	~1:10000	color	WA DNR	all of alluvial fan to the bridge crossing; misses part of the Skagit and upstream Illabot
1984	~1:15000	color	USDA Forest Service	upstream Illabot only
1989	1:40000	bw	USDA Forest Service	study area complete
1991	1:12000	color	USDA Forest Service	study area mostly complete -- misses very upstream portion of Illabot
1992	~1:12000	color	USDA Forest Service	misses northeastern portion of alluvial fan including east part of Illabot ponds, also a gap at the bridge crossing
1998	1:63360	bw	WA DNR	study area complete (orthophotos from DNR)
2001	1:12000	color	WA DNR	study area complete
2003	1:63360	color	WA DNR	study area complete (orthophotos from DNR)

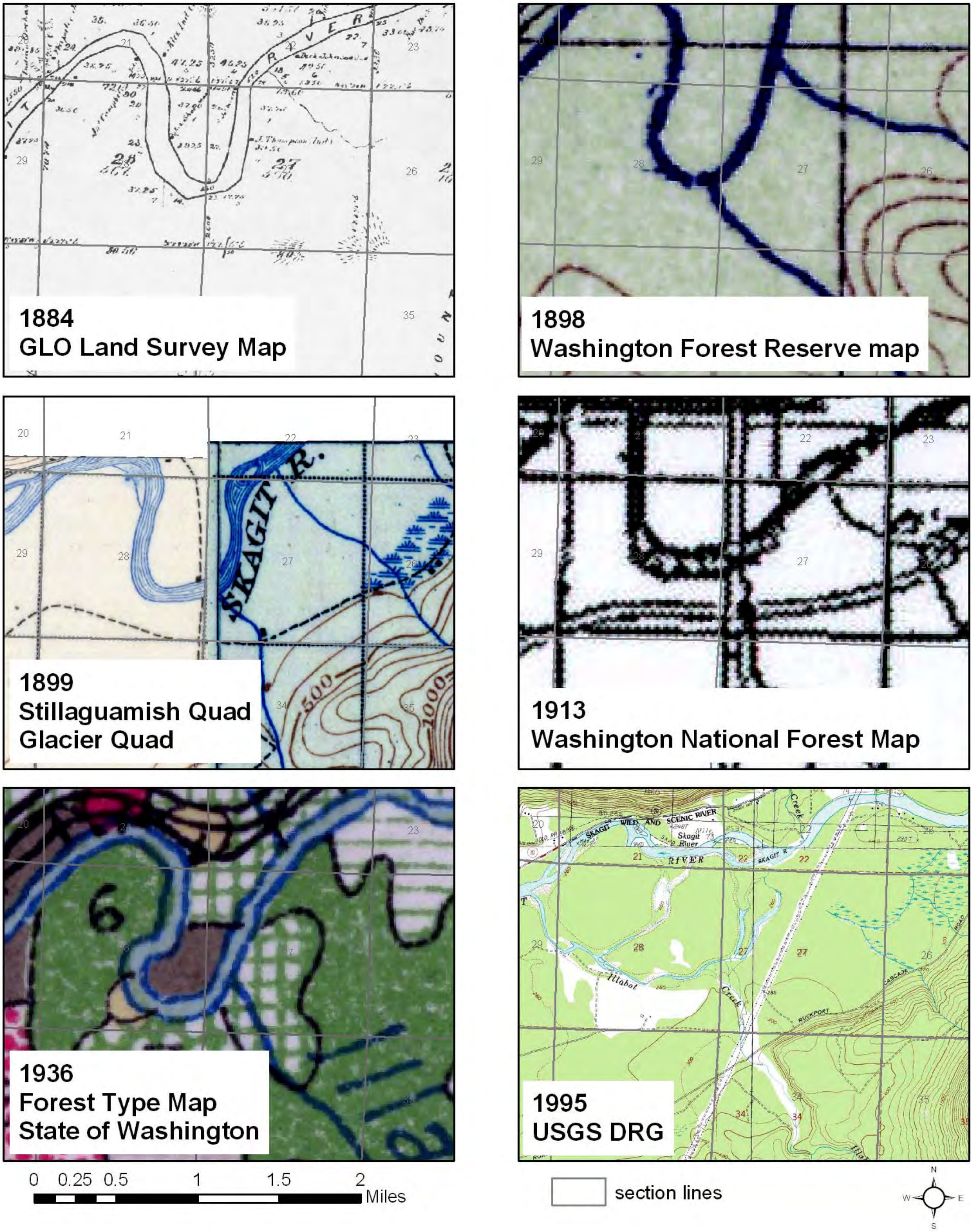
Table 3-1 Historic aerial photographs covering the Illabot Creek study area, except for 1944 photos and the 1998 and 2003 DNR orthophotos, were borrowed from photo libraries at the Mt. Baker and Darrington Ranger Districts of the Mt. Baker-Snoqualmie National Forest

Historic maps were also collected for the purpose of describing the historic conditions of the Skagit River near Illabot Creek during the pre-photograph record. General Land Office survey maps (1884) and historic topographic quadrangles (1899) were georeferenced by Collins and Sheikh (2002). Additional maps spanning the pre-photo record were downloaded from the University of Washington Libraries Map Collection website (http://www.lib.washington.edu/Maps), clipped to the study area and georeferenced using section corners.

Year	Map Name, Producer	Scale	Provided By
1884	General Land Office (GLO) survey map	1:31,680	Collins and Sheikh 2002
1898	Map of Washington Forest Reserve, Showing Distribution of Timber Species, USGS	1:380,000	University of Washington Map Library 2005
1899	Glacier and Stillaguamish USGS topographic quads	1:125,000	Collins and Sheikh 2002
1913	Washington National Forest map, USDA Forest Service	1:252,500	University of Washington Map Library 2005
1936	Forest Type Map, State of Washington, USDA Forest Service Pacific Northwest Forest Experiment Station	1:253,440	University of Washington Map Library 2005
1995	USGS DRGs (Rockport, Illabot Peaks, Marblemount, Sauk Mountain quads)	1:24,000	USGS 2002

Table 3-2 Historic topographic maps covering the Illabot Creek study area

Historic maps range in scale, accuracies, and purpose but when used in conjunction with other sources can be useful in reconstructing historical environments (Collins and Sheikh 2002). The historic maps used here are typically small-scale (covering a large area) and are mostly useful in describing general locations and characteristics of the Skagit River channel at this site (**Figure 3-1**). Collins and Sheikh (2002) mapped channel locations from the 1884 GLO maps and verified their accuracy by comparing field notes, other historic topographic maps, real topography, and historic air photos. The mapped location of the Skagit River at this site (on the GLO map) is considered to be of high certainty because it was field surveyed and therefore meandered. Stream channels were not field surveyed except to note locations where they crossed section lines, and unfortunately the Illabot Creek channel was not even sketched in on the GLO maps. Channels were digitized on the remaining historic maps to show and confirm the general location of the Skagit River throughout time previous to the air photo record (**Error! Reference source not found.**). The topographic maps indicate that previous to air photo availability, the mainstem Skagit River flowed downstream through what is now referred to as Illabot Ponds, and then meandered back up what is now referred to as Illabot Slough (Figures below). Currently, Illabot Slough flows in the opposite direction than what the historic mainstem river did through this spot. The exact date when the Skagit River began to occupy its current channel location is unknown. While the 1936 Forest Type Map indicates that the Skagit River was still occupying current-day Illabot Ponds and Illabot Slough, it is possible that it was a cartographic remnant from previous maps. It was estimated in section 2.2 that peak flows in the 10 year recurrence interval occurred in 1922, 1932, and 1934 and a 25-year recurrence interval in 1932. It is possible that the Skagit River avulsed into its current location during one of these peak flow events, likely due to a log jam that blocked and eventually diverted flow, and it is certain that it did so prior to 1943, the date of the first available air photo. It is not possible to determine what the historic conditions of Illabot Creek were like at this time using the historic topographic maps because of scale and mapping accuracy issues. The only thing that can be determined about Illabot Creek is that it seems to have occupied a similar location to the present day creek, and the mouth of Illabot was just below the current-day Illabot Ponds.


1884
GLO Land Survey Map

1898
Washington Forest Reserve map

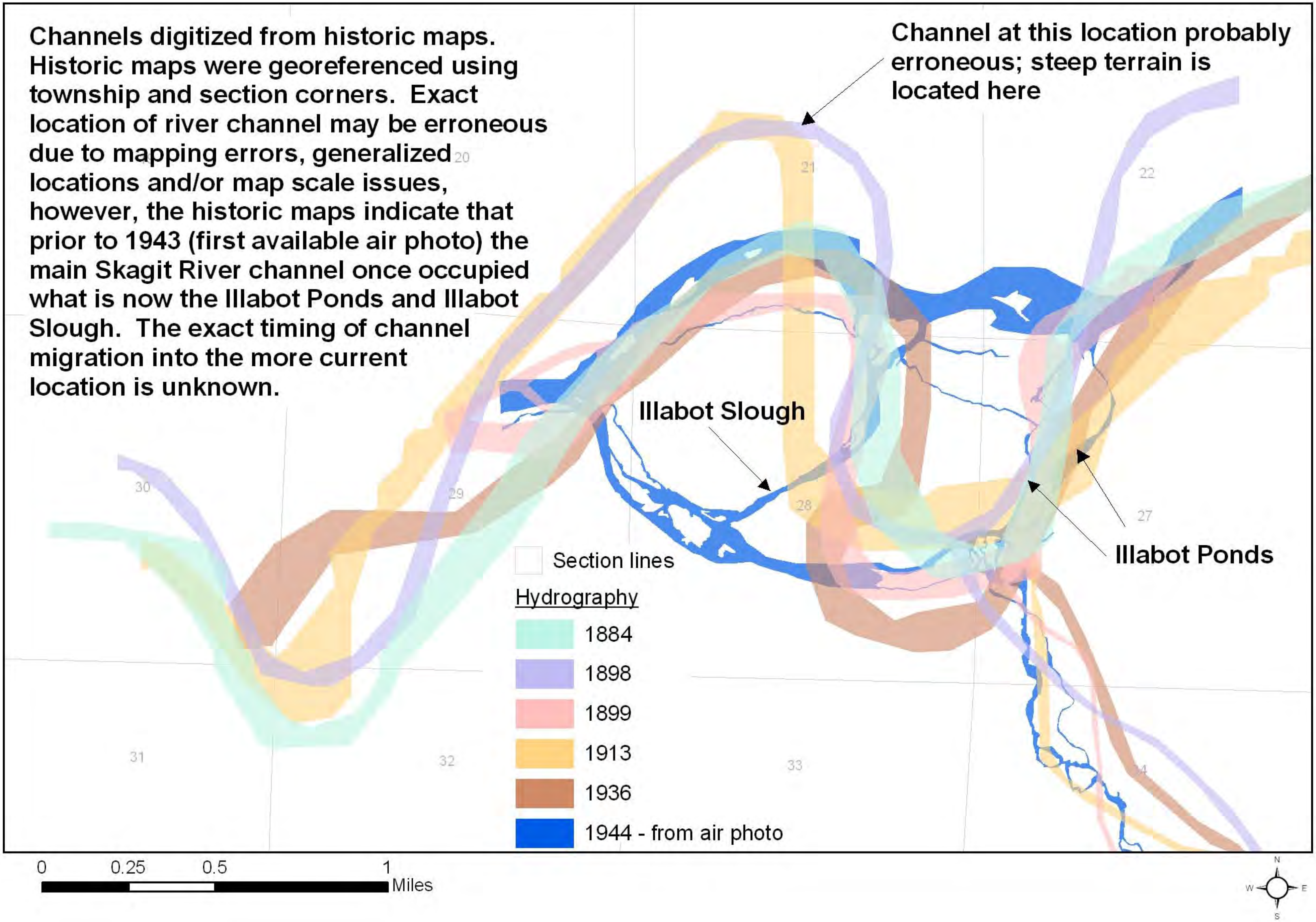
1899
Stillaguamish Quad
Glacier Quad

1913
Washington National Forest Map

1936
Forest Type Map
State of Washington

1995
USGS DRG

Figure 3-1 Historic topographic maps showing the Skagit River in what is now Illabot Slough



Channels digitized from historic maps. Historic maps were georeferenced using township and section corners. Exact location of river channel may be erroneous due to mapping errors, generalized locations and/or map scale issues, however, the historic maps indicate that prior to 1943 (first available air photo) the main Skagit River channel once occupied what is now the Illabot Ponds and Illabot Slough. The exact timing of channel migration into the more current location is unknown.

Channel at this location probably erroneous; steep terrain is located here

Illabot Slough

Illabot Ponds

Figure 3-2 Channels digitized from historic topographic maps

Aerial photographs are useful tools in mapping channel locations because they provide a snapshot in time in more detail than do topographic maps, in which the cartographer used their personal judgment in mapping features and, on smaller scale maps (which cover a broad area) smaller details that are important to this kind of study are typically left out. In order to compare changes in mainstem Illabot Creek and floodplain habitat channel locations and sizes throughout time, unvegetated channels were mapped from the air photos. In the GIS, unvegetated channels were identified and digitized as polygons for each photo year at a scale no closer than 1:3500 using the methods of Ward 2004 (Figure 3-3, Figure 3-4, and Figure 3-5). Unvegetated channels were mapped rather than attempting to map wetted channels because wetted channels were not always readily visible due to poor quality or color of the photo, scale issues, or canopy cover. Linear features that appeared to convey water or to have conveyed or been inundated by water recently (and therefore were unvegetated) were digitized. Comparisons were made from one photo year to the next to systematically identify channels of the same size that may otherwise have been missed due to varying photo qualities or scales. Channels that appeared to convey water were connected at their downstream end regardless of whether the outlet was visible on the photos. Figure 3-6 is an overlay of all the unvegetated channels that were mapped from the air photos, and shows where the most common location of Illabot Creek is over time (darker colors) and additional channels that represent additional possible locations that Illabot Creek could migrate into, flood channels, and generally represents the area of channel migration of Illabot Creek from 1943 to the present.

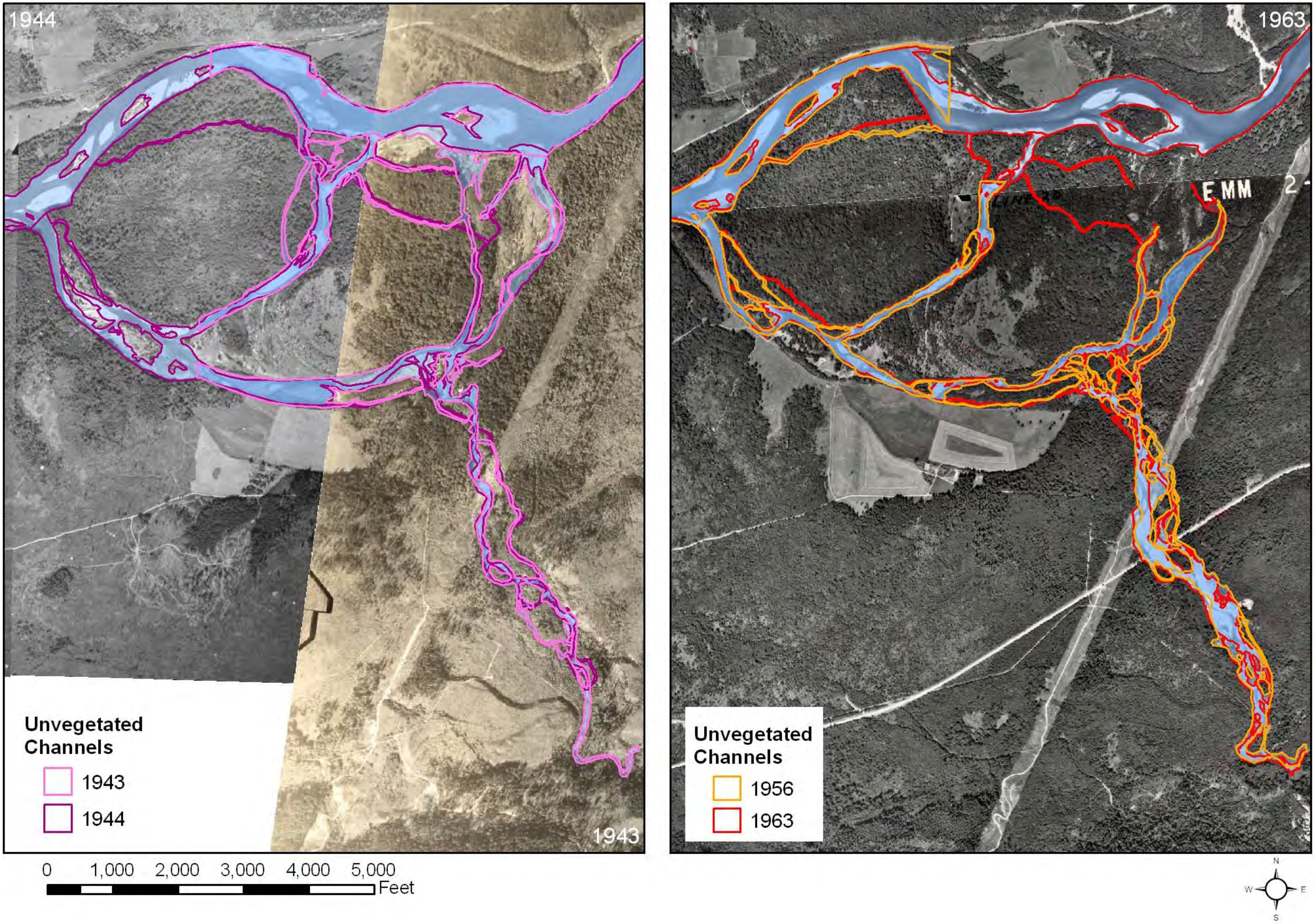


Figure 3-3 Channels digitized from historic air photos, 1943, 1944, 1956, and 1963

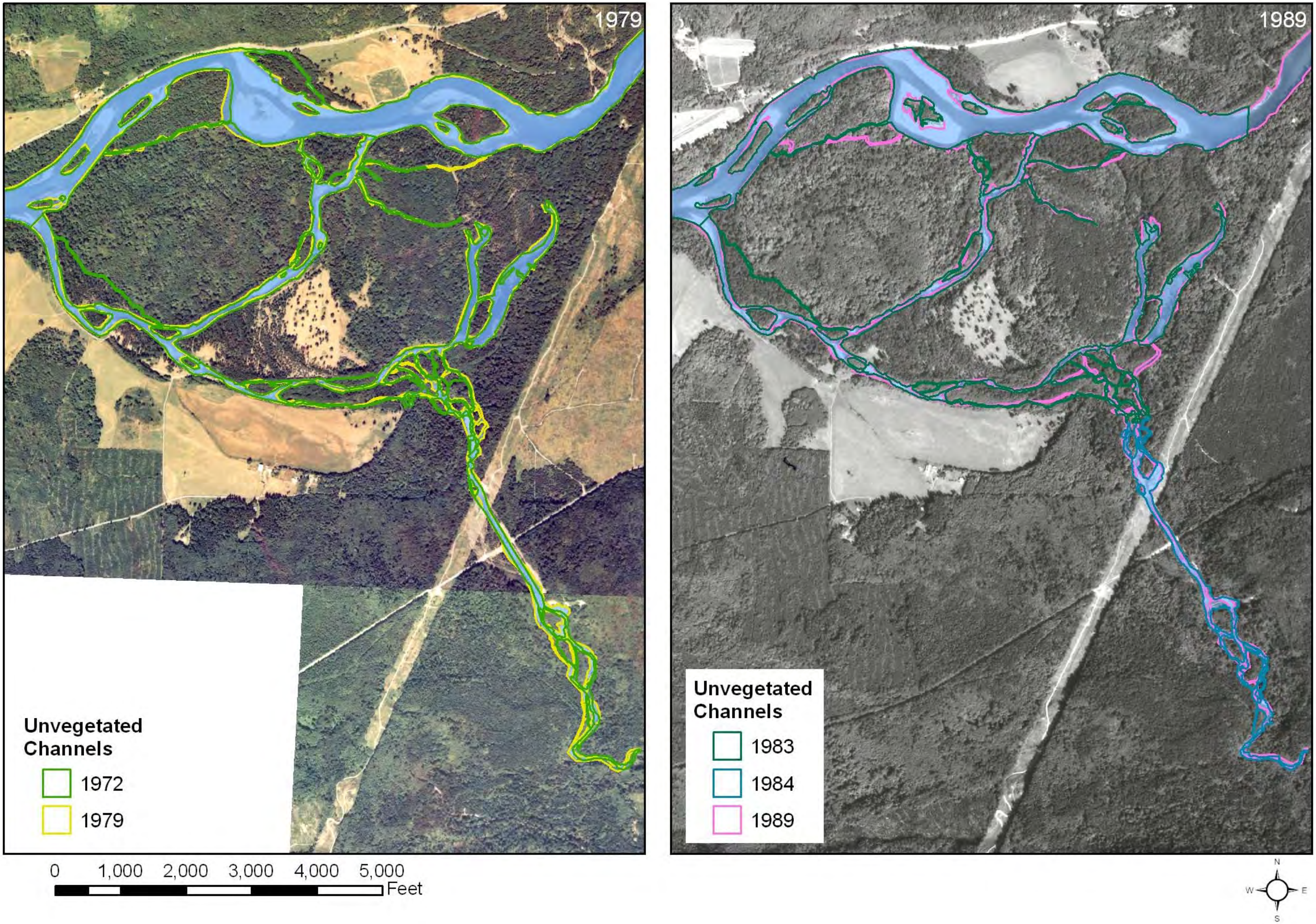


Figure 3-4 Channels digitized from historic air photos, 1972, 1979, 1983, 1984, and 1989

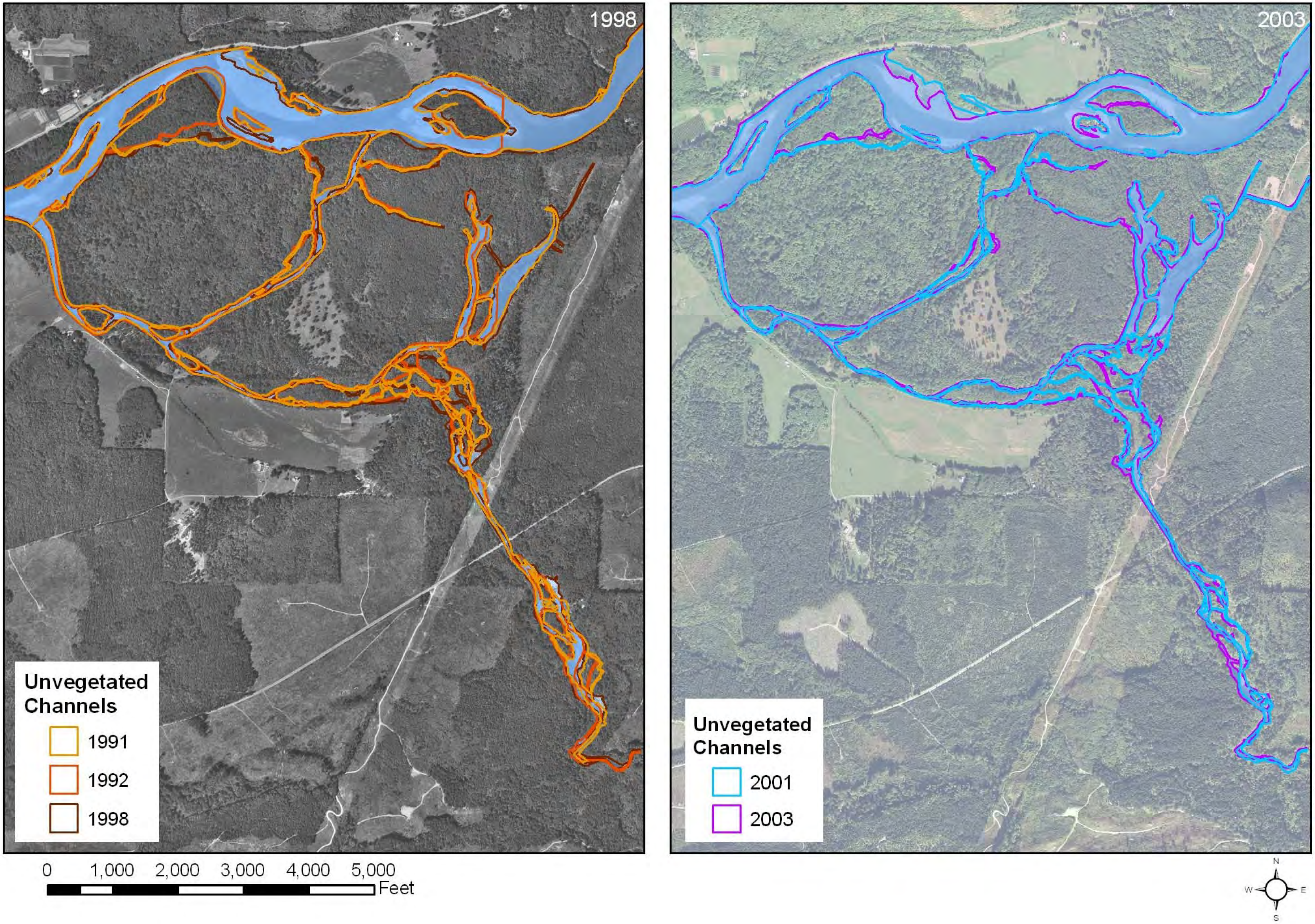


Figure 3-5 Channels digitized from historic air photos, 1991, 1992, 1998, 2001, and 2003

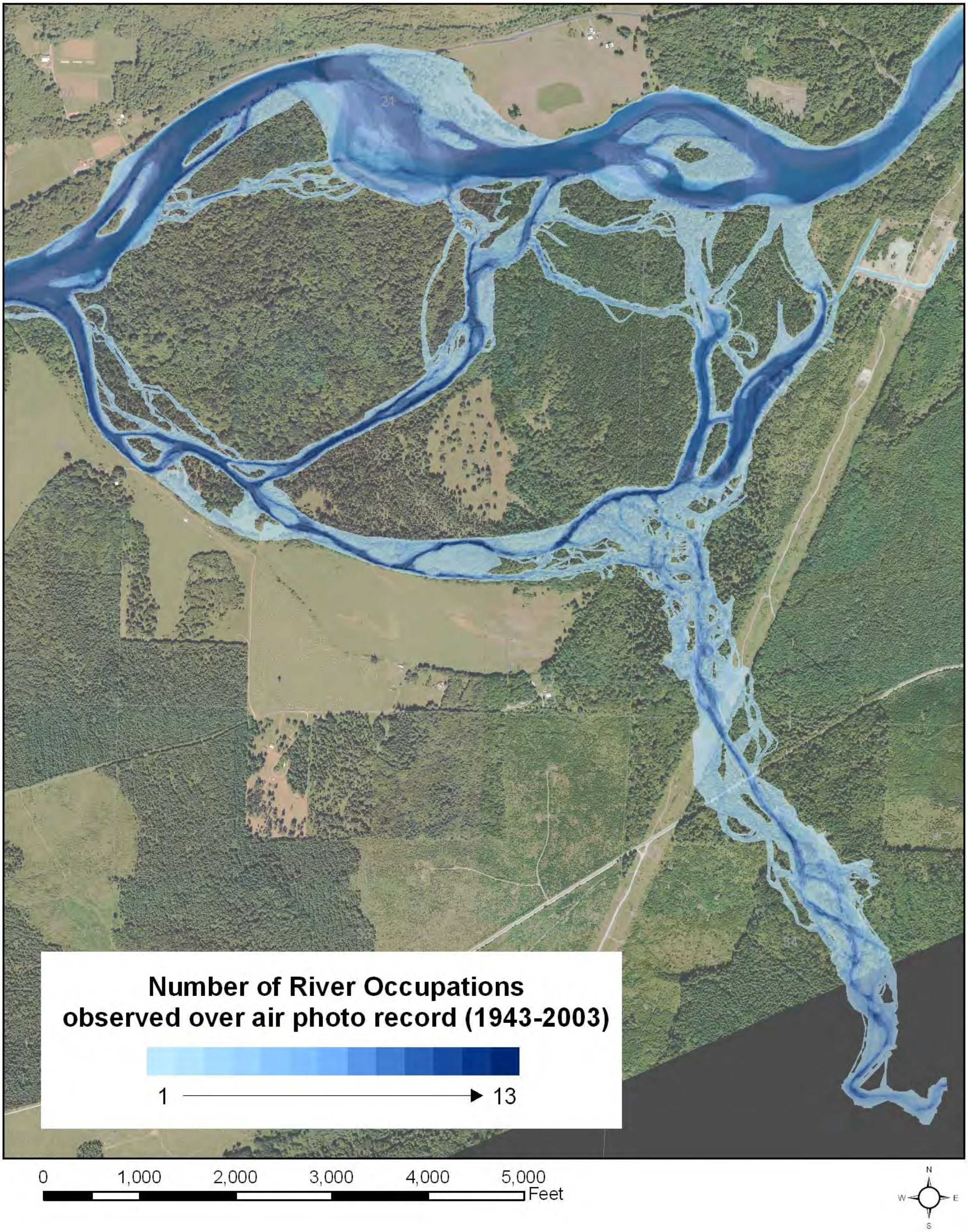


Figure 3-6 Overlay of channels digitized from historic air photos, showing river occupied locations

In closer detail, the air photos can be used to assess changes throughout time. The 1943 and 1944 air photos do show evidence of the historic river channel mapped on the earlier topographic maps. Unvegetated locations (which appear as a bright, white color on the black and white air photos) near the mouth of Illabot Slough indicate the recent presence of a lot of water; however other locations that the Skagit River occupied are starting to show signs of vegetation growth, such as in and around the Illabot Ponds, indicating the channel has not been in that location recently. Another place where the photos indicate or verify the topographic maps is the large clearing located between modern day Illabot Slough and reach 2 of Illabot Creek. In the 1940s photos, the patch is larger, has some vegetation but is mostly devoid of trees, and clearly indicates the flow direction of the old Skagit channel. This indicates that the Skagit has not been in this location for a while however the grainy air photos are not extremely useful for determining size of vegetation which would indicate how long the channel has or has not been there. There is also vegetation growing on an island in the newly formed Skagit River channel which looks to be pretty small yet. Another area with exposed channel location is where the historic Illabot mouth is, near the Illabot Ponds. This channel exposure is possibly due to a peak flow, exposing and/or depositing causing sediment or could also be due to logging, which there was quite of bit of it near the creek as evidenced by the 1940's photos. The 1940s photos also show Illabot Creek running in its historic path (pre-bridge) and also indicate a channel to the east of where the current channel is right now.

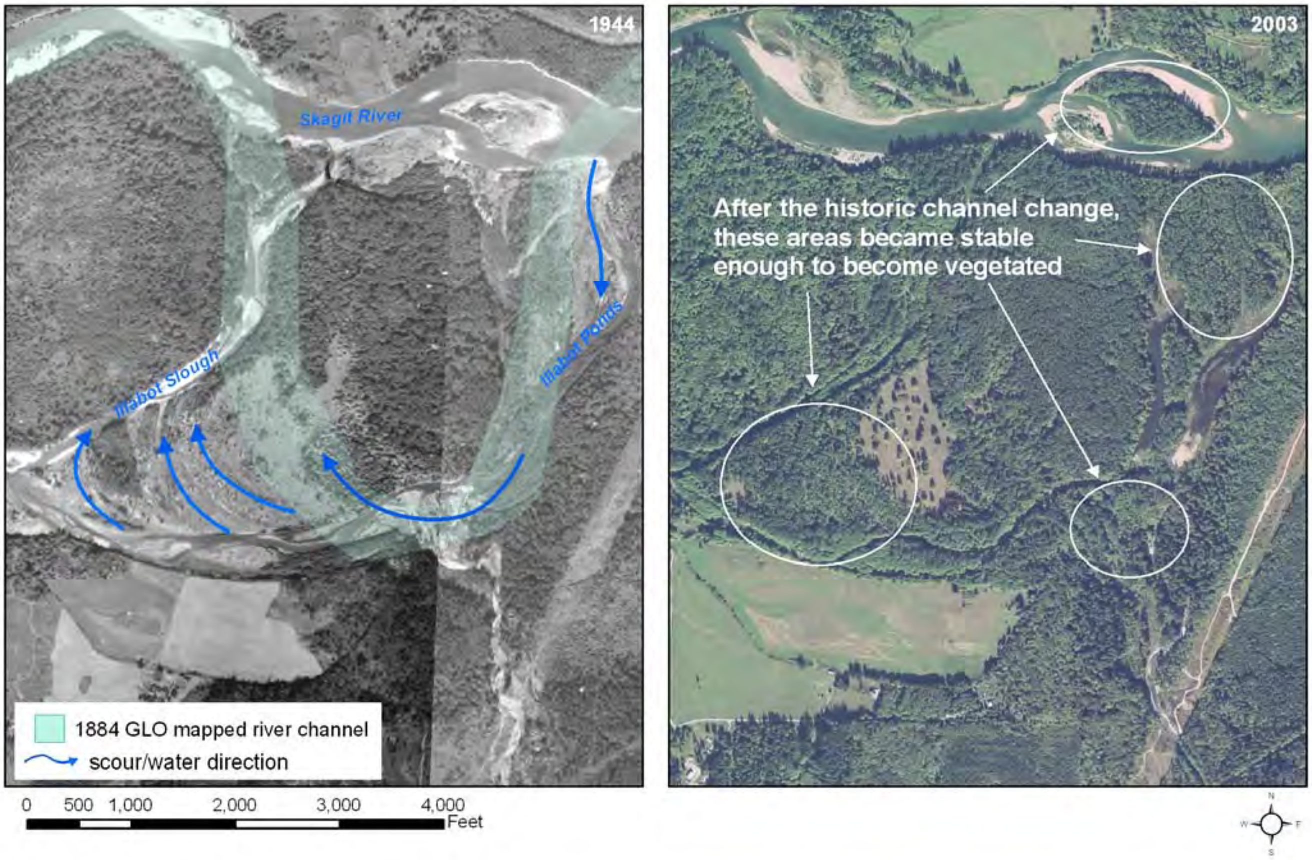


Figure 3-7 Detail of channel changes from 1944 to present

The 1956 air photo also indicates a peak flow event (see Figure 3-3); there is a lot of exposed channel in this air photo, more so than in any other photo available in the air photo record. This may have been a result of the 10 year flow in 1950 or 25 year flow in 1951, or a combination of both. The Illabot Ponds are wetted but unfortunately a photo which would have shown the Skagit River near the ponds is not available, which would have indicated whether or not there was an overflow channel connection from the Skagit River to the Illabot Ponds at this time. Illabot Creek near the present day bridge crossing shows multiple channels on either side of the present day channel, showing how, when unconstrained, the Illabot Creek channel in the location of the bridge crossing, has the ability to migrate around and be a braided channel like the reaches downstream. In 1956 photo, vegetation has established at the location where the Illabot Creek mouth was historically when the Skagit River channel ran down the ponds and up the slough. By 1963, even more so, these channels appear stable and vegetation has established and is becoming mature.

Illabot Slough has been fairly stable over the air photo record. It enters the floodplain from Skagit River left bank and flows down to Illabot Creek. There is one main inlet from the Skagit River and another smaller channel that is well established in the 1944 photo, perhaps a remnant from where the Skagit River used to flow. Water is visible in this channel in every color photo available although by 1998 it appears that there is less water running into this channel due to the development of a sandbar at the mouth of this channel, cutting off the inlet of the channel from the main Skagit River and feeding it through a backwater. There are also a couple of sloughs entering into Illabot Slough on its left bank, the sources of which are the Skagit River and the Illabot Ponds. The exact connections are difficult to see on the air photos so they might be partially groundwater fed. The north-most slough appears to be at what was once the bank of the Skagit River, or a channel which was carved by the Skagit during a peak flow. It is possible the riparian vegetation at this location was logged many decades ago, as it appears there might be a road or path visible on the 1940s air photos, since which time riparian vegetation has developed around the lower channel. The Skagit River has migrated/meandered over the photo record and taken out a portion of the floodplain upstream of the mouth of Illabot Creek. The progression is quite clear on the air photos, and each air photo from 1944 to 2003 shows that the floodplain has been eroding away in this spot. There is a side channel at this location as well – it has been shortened by the Skagit River eroding away at this spot but it is still present today and was verified in the field.

Additional features that are visible in the air photos are land use changes such as farm expansion and timber harvest. Farms have always been present on the Illabot Creek air photo record starting in 1943 and they have expanded from one photo to the next, so that by 1963 a good portion of the agriculture in this area is established to an extent similar to that of today, and a distance along Illabot Creek has been devoid of a wide buffer for riparian vegetation (less than 40 meters in width, see discussion of riparian buffers in Section 4.2).

Year	Length of Impaired Stream (ft)
1944	1400
1956	2200
1963	3400
1972	4500

Table 3-3 Stream length along which agriculture is located, estimated from air photos

Table 3 estimates the extent of the expansion of agriculture along Illabot Creek; after 1972 the riparian area began to fill in, and in 2003 the length of impaired riparian habitat along Illabot Creek was about 3900 ft. In the 1960s and 1970s air photos a small bridge is also visible, crossing Illabot Creek in the vicinity of the farms with a small road or trail visible on the other side of Illabot Creek leading to and skirting the perimeter of the large clearing. The bridge and road may have allowed cattle access to grazing in the small openings on the floodplain and may have provided an access road for some of the timber harvesting that was done on the floodplain and alluvial fan area in the 1960s and 1970s. Currently the bridge does not exist, although cattle may still have access to the floodplain on parcels that are managed for conservation purposes (Barkdull, personal communication).

The biggest change to Illabot Creek throughout the air photo record is the channelization of Illabot Creek because of the Rockport-Cascade bridge crossing (see Section 4.4 Hydromodifications and Appendix A for figures). The 1940s and 1956 air photos show Illabot Creek as a meandering, multiple-channel creek at this location. In the 1956 photo the area of channel migration is very clear because of all of the exposed gravels due to peak flows in the years prior. This activity zone measures around 600-700 feet across. Once the bridge crossing was constructed during the 1970s, though, the channel is constrained by the dikes and the stream is not allowed to take the multiple pathways that it used to. The dikes not only constrain the side-to-side movement but the water appears constrained immediately downstream as well. The 1984 photo shows that the Illabot Creek channel did migrate at the downstream end of the riprap, towards and behind the powerline tower into what was a former historic channel. The original dikes did not extend quite that far downstream in the original late 1960’s plan and an additional berm was placed there in late 1980’s or early 1990’s (water is still visible behind the powerline tower in the 1989 photo) and cut off this channel from going behind the tower in the future. By the 1991 photo the berm is in place and Illabot Creek is once again in the straightened channel. Just downstream of the dikes, Illabot Creek created a new channel between 1979 and 1984 in line with the constructed channel, possible due to the flow of the constructed channel. By 1991 this channel is wide (the unvegetated channel is 150 f across) with a fair amount of wood in it. However by 2001, this channel has started to grow in with vegetation and Illabot curves off again to the northeast like it is currently doing.

Upstream of the channelized reach, Illabot Creek drops out of a canyon and Illabot Creek meanders down to the modified reach. At one point between 1956 and 1963 there was a landslide on the right bank of the creek upstream from the bridge. In the 1984 photo it is clear that Illabot Creek uses the pathway that the landslide created and starts eroding the right bank near the upstream end of the dike material. By 1991, Illabot Creek created a channel straight through that bank and took out a portion of the dike material about 600 or 700 feet upstream from the bridge. By 1998 it looks like Illabot continued to use this channel because it became fairly unvegetated, but then by 2001 and 2003, this channel is being vegetated again and it looks like Illabot is using its main channel through there.

Channel paths not clearly visible on air photos, or that pre-date the air photos because they are historic channels, may also be visible as depressions on the landscape on elevation models. LiDAR was flown for this study area in 2005 and processed by TerraPoint. The LiDAR shows features in the topography that are not readily visible on digital air photos and in fact may show channels that were historically occupied by Illabot Creek or the Skagit River. In GIS, the LiDAR was transformed into a hillshade, and lines were digitized where it appeared that channels have historically conveyed or presently convey water from Illabot Creek. Channels appear on either side of Illabot Creek both upstream and downstream of the current bridge crossing, some of which were visible on the air photos and some were not but since they identify low ground these are places where Illabot Creek has been or could potentially flow. Most of the channels on the east side of Illabot Creek near the powerline towers have been mapped throughout the air photo record, excluding the channels that were mapped heading up towards the ponds. On the west side of Illabot Creek, there are several channels that were mapped off of the hillshade that were not mapped in the air photo record. These branch off of what is now the mainstem Illabot and rejoin further downstream and could be old overflow channels or old channels of the creek. There are also a couple channels that branch off of Illabot Creek near the current bridge crossing and end up branching out and water potentially had several different pathways it could have gone. One was to head towards the Martin Ranch Farm and meet the main channel at that point. The other direction is to head west toward the complex of what are now Lucas and Barnaby Sloughs, remnant channels of the Skagit River. From there, there are many different ways that Illabot Creek could have reached the Skagit.

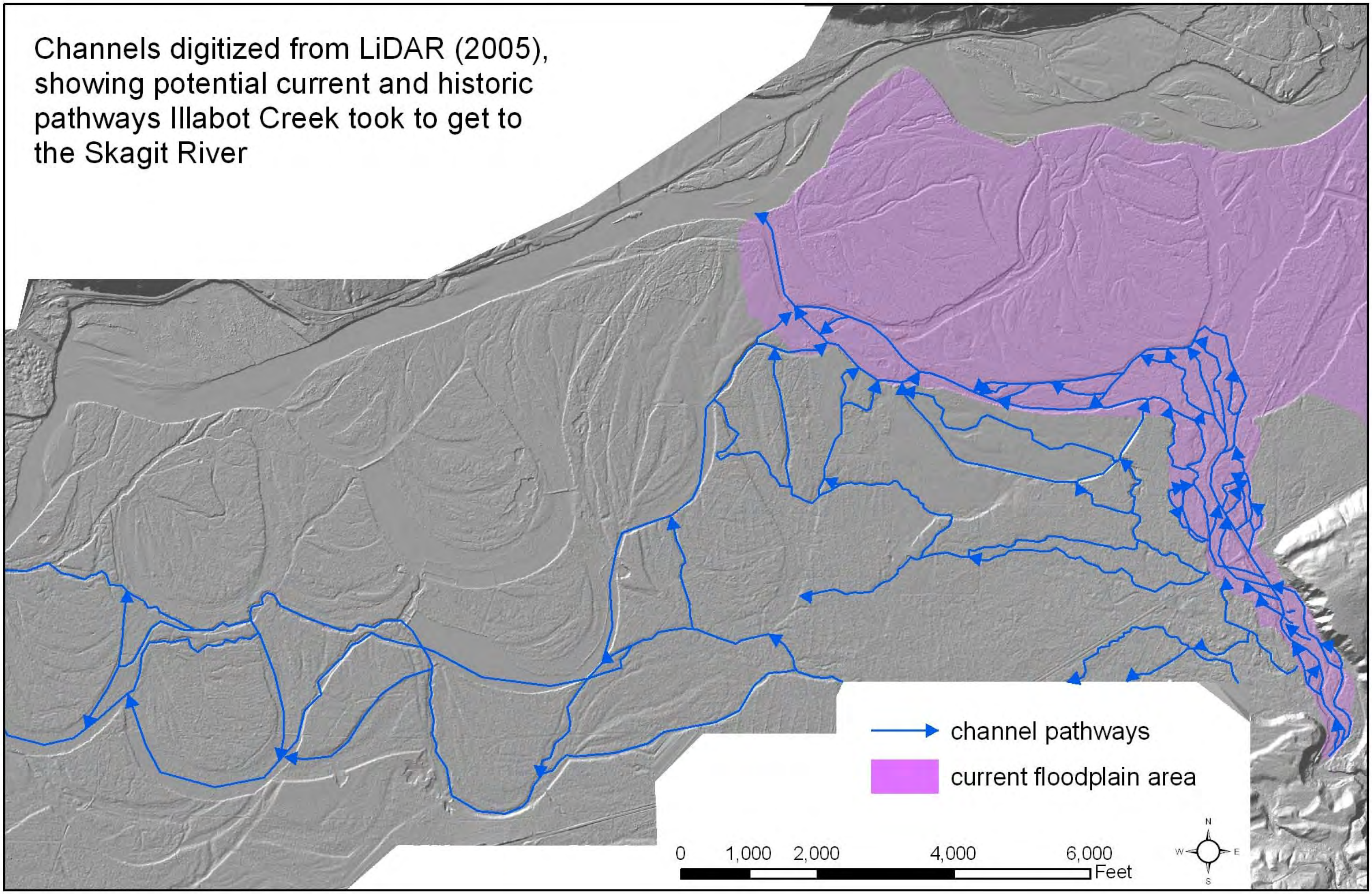


Figure 3-8 Channels (current and historic) digitized from LiDAR hillhade

3.2 CURRENT INSTREAM CONDITIONS

Instream habitat conditions were characterized for the Illabot floodplain/alluvial fan reach using a combination of existing data, aerial photograph interpretation, and field work. Habitats that were generally associated with the Skagit River floodplain and groundwater from the river were characterized separately from habitats associated with the Illabot Creek channel and surface water from the creek. The results are described below for each of these two groups of habitat types.

3.2.1 Floodplain Habitat

Off-channel habitats in the Skagit River floodplain are low-gradient, often occupy historic channels of the river, and are generally fed by groundwater from the river or small surface water streams. These kinds of habitats provide important spawning habitat for species such as chum salmon and winter rearing habitat for juvenile coho salmon, and are used to some extent by a variety of other species and life stages. The portion of the Skagit River floodplain associated with Illabot Creek has an abundance of off-channel habitat.

Much of the off-channel habitat associated with Illabot Creek was characterized using information from an existing off-channel habitat inventory for the upper Skagit basin (Smith 2005). Habitats that were not included in that inventory were characterized for this study. All habitats were classified by habitat type and water source, and the wetted area for moderate winter flow conditions was measured using aerial photographs and wetted width measurements taken in the field. Spawning habitat area was measured for habitats from the previous off-channel habitat inventory and is presented here, but was not measured for habitats inventoried for this study.

Habitats types included sloughs, ponds, and overflow channels. Sloughs were defined as having low to moderate velocities during normal winter flows, dominated by pools with limited gravel, and fed predominantly by groundwater or a combination of surface water and groundwater. Ponds were similar to sloughs except slower moving, > 3 m in depth and greater than 20 m in width. Overflow channels had a regular surface water connection with the river during higher flows which means they have high velocities in the winter, are dominated by riffle habitat, and have an abundance of gravel substrate. Overflow channels were only included if they were wetted with low velocities during more moderate winter flows, so channels that are dry except during flood events were not included. Water source was classified as groundwater, surface water from the river or hillslope, or a combination of both.

A map showing these habitats is provided in Figure 3-9 and a summary of floodplain habitat conditions is provided in Table 3.3 and Figure 3-10. The results show a total winter wetted area of 207,355 square meters, of which the vast majority is in ponds and sloughs that are fed by groundwater or a combination of surface and groundwater during most winter flows.

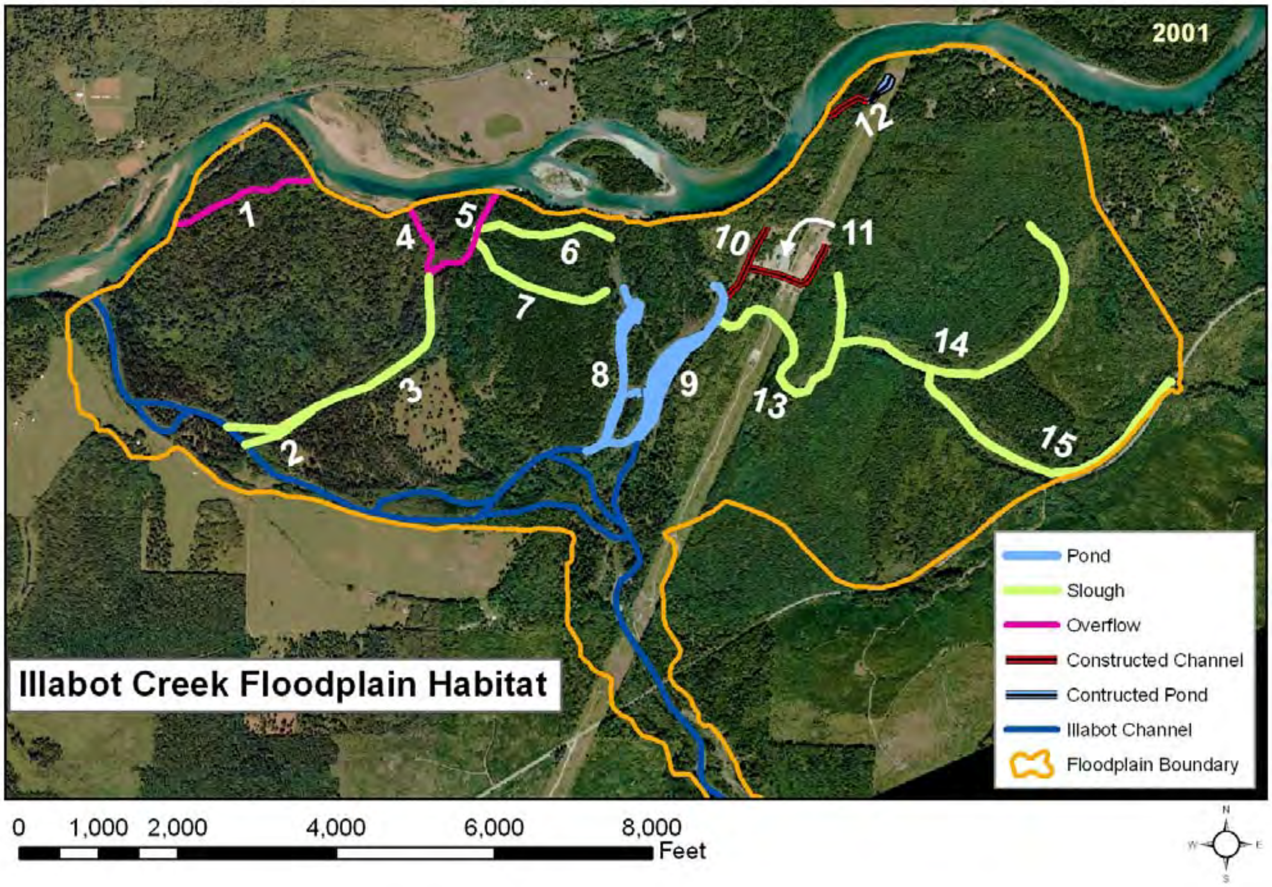


Figure 3-9. Map of floodplain habitats and reach numbers

Reach #	**Name**	**Habitat Type**	**Length (m)**	**Mean winter wetted width (m)**	**Winter wetted area (m^2)**	**Spawning habitat area (m^2)**	**Water source**
1		Overflow	583	6	3,498	?	Combo
2	Lower Illabot Sl	Slough	293	7	2,051	?	Combo
3	Lower Illabot Sl	Slough	1,124	10	11,240	?	Combo
4		Overflow	292	3	876	?	Combo
5		Overflow	455	5	2,275	?	Combo
6		Slough	539	5	2,695	?	River groundwater
7		Slough	599	7	4,193	?	River groundwater
8	Illabot Pond 1	Pond	658	41	26,978	200	River groundwater
9	Illabot Pond 2	Pond	928	37	34,764	0	River groundwater
10	Illabot Channel	Constructed Channel	308	7	2,156	1,876	River groundwater
11	Illabot Extension	Constructed Channel	402	9	3,807	3,126	River groundwater
12a	Powerline Channel	Constructed Channel	183	5	915	?	River groundwater
12b	Powerline Channel	Constructed Pond	67	24	1,635	?	River groundwater
13	O'Brien Creek complex	Slough	1,162	18	21,180	675	Combo
14	O'Brien Creek complex	Slough	1,328	30	39,735	0	Combo
15	O'Brien Creek complex	Slough	1,250	40	50,000	675	Hillslope surface water
Total			**10,171**		**207,998**	**6,552**	

Table 3-4 Characteristics of floodplain habitat associated with Illabot Creek

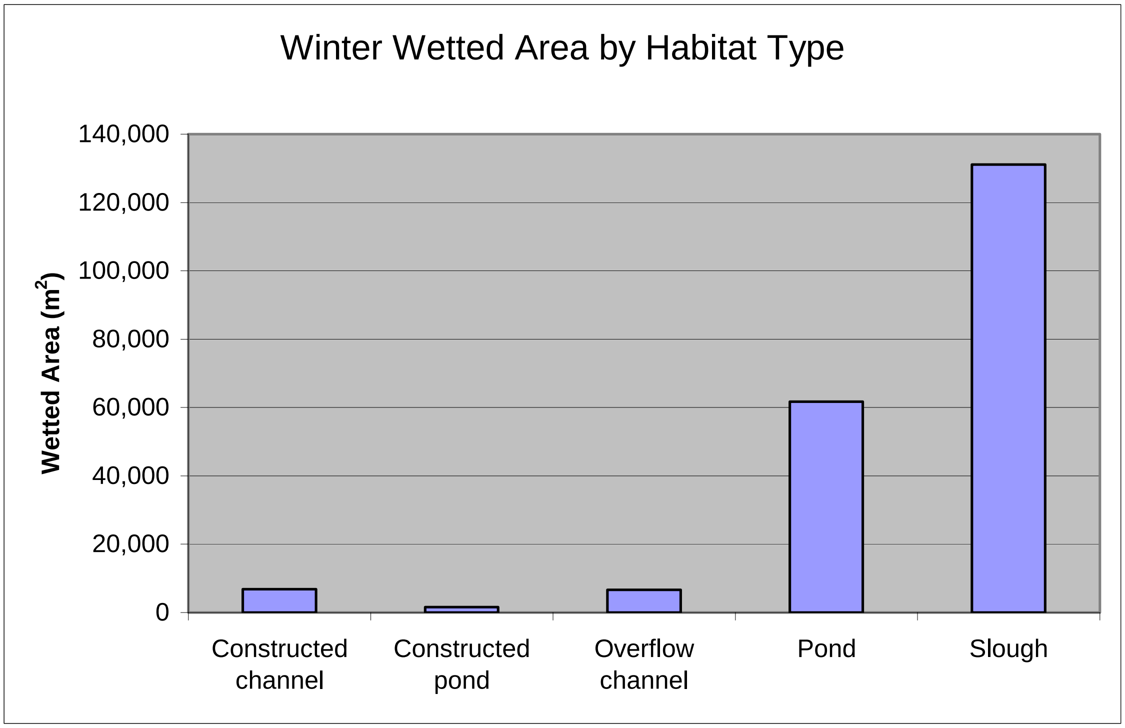


Figure 3-10. Winter wetted area by habitat type for floodplain habitats associated with Illabot Creek

3.2.2 Illabot Creek Habitat

Habitats in the Illabot Creek channel were evaluated separately from those associated with the Skagit River floodplain because they have different characteristics and habitat values. While groundwater from the Skagit River contributes some flow to these channels in the lower reaches, the majority of the flow is surface water from Illabot Creek. These channels generally have steeper gradients, higher velocities and more abundant sediment transported from the mountainous upper watershed. These channels provide the majority of spawning habitat for most fish species, abundant summer rearing, and also some winter rearing for juvenile coho but to a much smaller extent than for floodplain habitats.

All of the habitat information presented here was taken from Beamer et al. (1998). These data were collected during the 1994 season and there have certainly been changes in channel conditions since that time. However it is expected that the general pattern of reach characteristics is similar now and it was not necessary to collect new habitat information with the level of detail in Beamer et al. (1998) for the purposes of this feasibility study. All habitats were classified based on habitat type and the following information was collected: channel gradient from maps and field, length, wetted width, bankfull width, area and length of habitat units (pools, riffles, glides), and number of large woody debris pieces.

Habitats were classified based on the channel type system from Montgomery and Buffington (1997). Pool:riffle (PR) channels are commonly found at channel gradients between 0.5% and 2%, have pool spacings of < 4 channel widths per pool and the dominant pool-forming mechanism is lateral scour so pool formation occurs in the absence of channel obstructions such as wood or bedrock. Plane bed (PB) channels are typically found at gradients between 2% and 4%, have a pool spacing of > 4 channel widths per pool due to a lack of channel obstructions such as wood or bedrock, and are dominated by riffle area. Forced pool:riffle (fPR) are found at channel gradients between 0.5% and 4%, have pool spacing of < 4 channel widths per pool, and greater than 50% of the pools are formed by obstructions such as wood or bedrock. Pool:riffle and forced pool:riffle channels generally have much better habitat conditions and greater fish use than plane bed channels or channels with gradients steeper than 4%.

A map showing the habitat reaches is provided in Figure 3-11 and a summary of their characteristics is provided in Table 3-5. These data show the lower reaches 1 and 2 in the Skagit River floodplain are pool:riffle channels with low gradients and abundant pools. Reach 3 has multiple forced pool:riffle channels as a result of sediment deposition as the gradient begins to flatten out on the floodplain, also with abundant wood and pools. Reach 4 is a moderate gradient forced pool:riffle channel, reach 5 is a moderate gradient plane bed channel as a result of dikes and rip-rap armoring and has few pools or large woody debris. Reach 6 is a moderate gradient and is forced pool:riffle in the lower end and plane bed in the upper end.

Habitats and fish use continue for several miles upstream of reach 6, but these are not considered here because the gradients are generally steeper and the habitat is correspondingly less productive and because the area upstream of the alluvial fan is beyond the scope of this feasibility study.

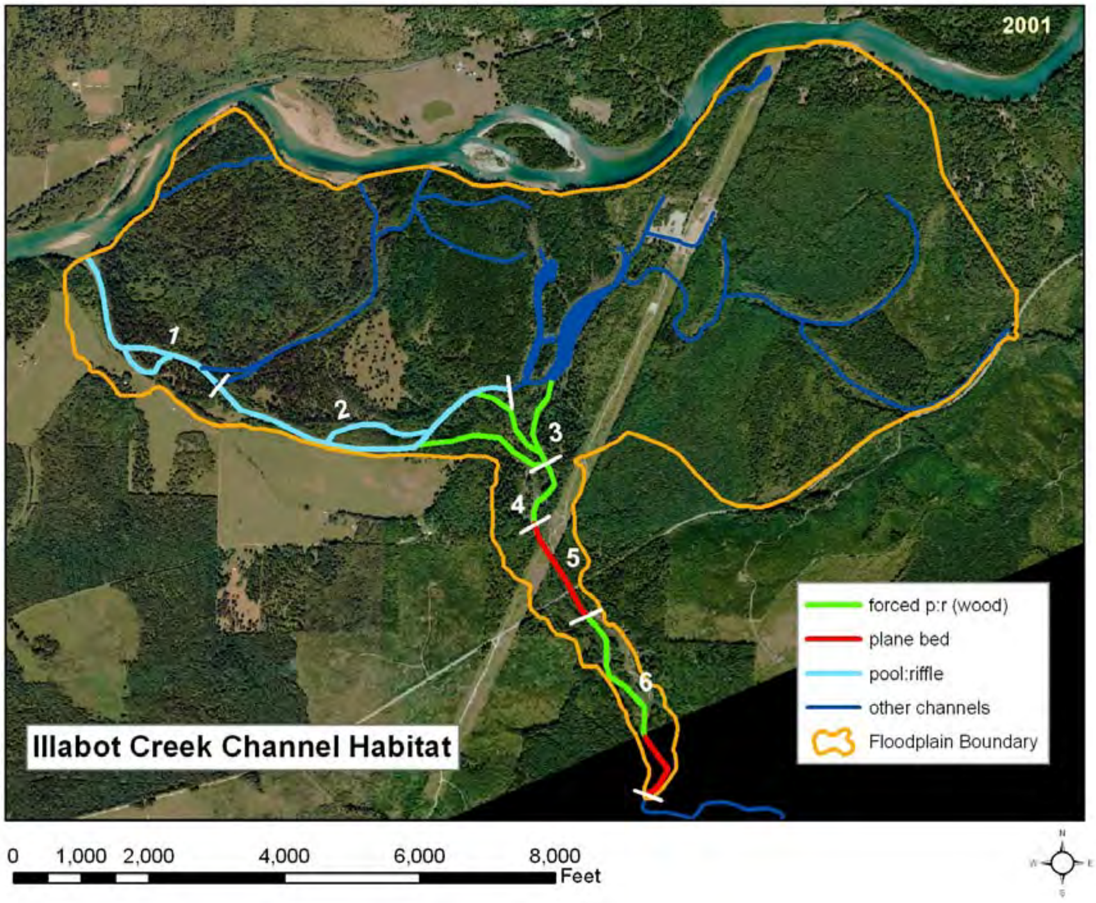


Figure 3-11. Map of channel habitats and reach numbers

Reach	Channel type	Length (m)	Map gradient	Mean bankfull width (m)	# pools	Pool forming factor	Pool spacing (CW/ pool)	LWD pieces / 100m
1	PR	940	0.2%	41	3	bank scour	7.6	7.1
2	PR	950	0.2%	31	13	bank scour	2.4	10.2
2.1	PRw	691	0.2%	16	11	bank/wood	3.9	11.7
2.2	FPRw	480	0.2%	14	17	wood	2.0	34.6
2-#3	FPRw	50	0.2%	12	3	wood	1.4	38.0

2-#4	PR	241	0.2%	14	2	wood	8.6	6.6
3	FPRw	540	0.8%	13	16	wood	2.6	27.2
3-#1	FPRw	358	0.8%	7	15	wood	3.4	26.5
3-#6	FPRw	172	0.8%	10	6	wood	2.9	30.2
4	FPRw	370	1.2%	19	14	wood	1.4	72.2
5	PB	510	2.4%	17	3	rip-rap	10.0	5.7
6	FPRw	605	1.5%	17	9	wood	4.0	52.2
6-#1	PB	378	1.5%	11	3	wood	11.5	7.4
6-#3	PB	357	1.5%	6	2	wood	29.8	1.4
6-#4	PB	164	1.5%	6	0	no pools	N/A	0.0
6.2	PB	450	2.0%	26	0	no pools	N/A	18.0

Table 3-5 Illabot channel habitat characteristics from Beamer et al. 1998

4 HABITAT IMPACTS

4.1 SEDIMENT IMPACTS

There has been quite a bit of work on sediment issues in the Illabot Creek watershed. This has included an inventory of sediment delivery to streams from mass wasting in the upper watershed (Paulson 1997), restoration treatments on forest roads to reduce sediment inputs to Illabot Creek by the Forest Service and in O'Brien Creek by Seattle City Light, and a monitoring project to evaluate the effectiveness of sediment reduction efforts in Illabot Creek (Beamer et al. 1998).

The work of Paulson (1997) showed a significant increase in sediment production caused by roads in the past several decades but that sediment supply overall in Illabot Creek was less than 150% of background rates, which is relatively low compared to other heavily managed watersheds in the Skagit River basin. Beamer et al. (1998) evaluated conditions in lower-gradient response reaches downstream from sediment inputs in Illabot Creek and determined that residual pool depths had not increased sufficiently to detect a change as a result of road improvement projects. But because sediment supply rates were already relatively low, they concluded that there were not ongoing impacts from forest roads and the best approach was to monitor for negative changes in the future.

4.2 RIPARIAN AND FLOODPLAIN VEGETATION IMPACT

For the purposes of assessing large woody debris recruitment and riparian and floodplain condition, overstory vegetation was mapped remotely for the Illabot alluvial fan and floodplain area with 1:12,000 color aerial photograph stereopairs from 2001 (air photo source: DNR) and a stereoscope, using methodology modified from Washington Forest Practices Board 1997. These methods lump overstory vegetation into broad categories of species and size based on their expected habitat value in riparian stands (Table 4-1).

Species		**Size Class**	
Conifer Dominated	≥70% conifer species	**Large**	≥20 inches average diameter
Hardwood Dominated	≥70% hardwood species	**Medium**	≥12 and <20 inches average diameter
Mixed	All others	**Small**	< 12 inches average diameter

Table 4-1 Overstory vegetation categories

Interpretation of dominant vegetation types (conifer versus hardwood) was based on methods in Avery and Berlin 1985. The Washington Forest Practices Board vegetation classes were used to characterize forest stands across the Illabot Creek floodplain and alluvial fan study area. Overstory vegetation types were observed on the stereopairs and digitized as polygons in a GIS to generate maps of riparian and floodplain vegetation.

Portions of the overstory vegetation maps were verified during field visits and subsequent vegetation mapping of the Illabot floodplain was completed by comparing field-checked units to the aerial photos (Figure 4-1). The area of each vegetation type was calculated and is presented in Table 4-2. As mapped from the 2001 stereopairs, floodplain vegetation at this site is dominated by mixed species type of medium size (41.1%) and hardwood dominated type of medium size (23.5%). Field visits to the site verified that hardwood dominated types, especially in the medium size class category, are not pure hardwood stands and they do contain medium sized conifer species. Conifer dominated stands comprise about 14% of the floodplain, or almost 200 acres, mostly in the medium size class category. Some of this area covers former timber harvest units, which were replanted with conifer species. In late 2005, approximately 8.3 acres of conifer dominated, medium sized forest near the Rockport-Cascade Road bridge crossing was removed through timber harvest which would reduce this vegetation category to 12% of the floodplain. When planted, it will be replaced by a conifer dominated stand with a small size class. Historical aerial photographs indicate that much of the floodplain has been logged in the past (based on air photo interpretation, at least 560 acres on the Illabot Creek floodplain have been timber harvested from 1944 to the present, with some of the harvest boundaries overlapping throughout time), however presently over 87% of the floodplain is forested, much of which is protected within a conservation land ownership. Conditions of floodplain forest are likely to continue to improve because of this protected status, with tree sizes becoming larger and more conifer species establishing.

Land Cover Type	**Size**	**Acres**	**% of Floodplain**
Conifer Dominated	Large	13.1	0.9
	Medium	181.6	12.6
	Small	4.7	0.3
	Total	**199.7**	**13.8**
Hardwood Dominated	Medium	339.8	23.5
	Small	130.0	9.0
	Total	**469.8**	**32.6**
Mixed	Medium	592.7	41.1
	Small	0.9	0.1
	Total	**593.7**	**41.1**
Forested	**Total**	**1263.1**	**87.5**
Non-Forested:			
Powerline Corridor		57.2	4.0
Rockport-Cascade Road		1.0	0.1
Agriculture		15.4	1.1
Cleared (Not Agriculture)		26.5	1.8
Water		80.0	5.5
	Total	**180.2**	**12.5**
Grand Total		**1443.3**	

Table 4-2 Summary of floodplain overstory vegetation, mapped from stereopairs (2001)

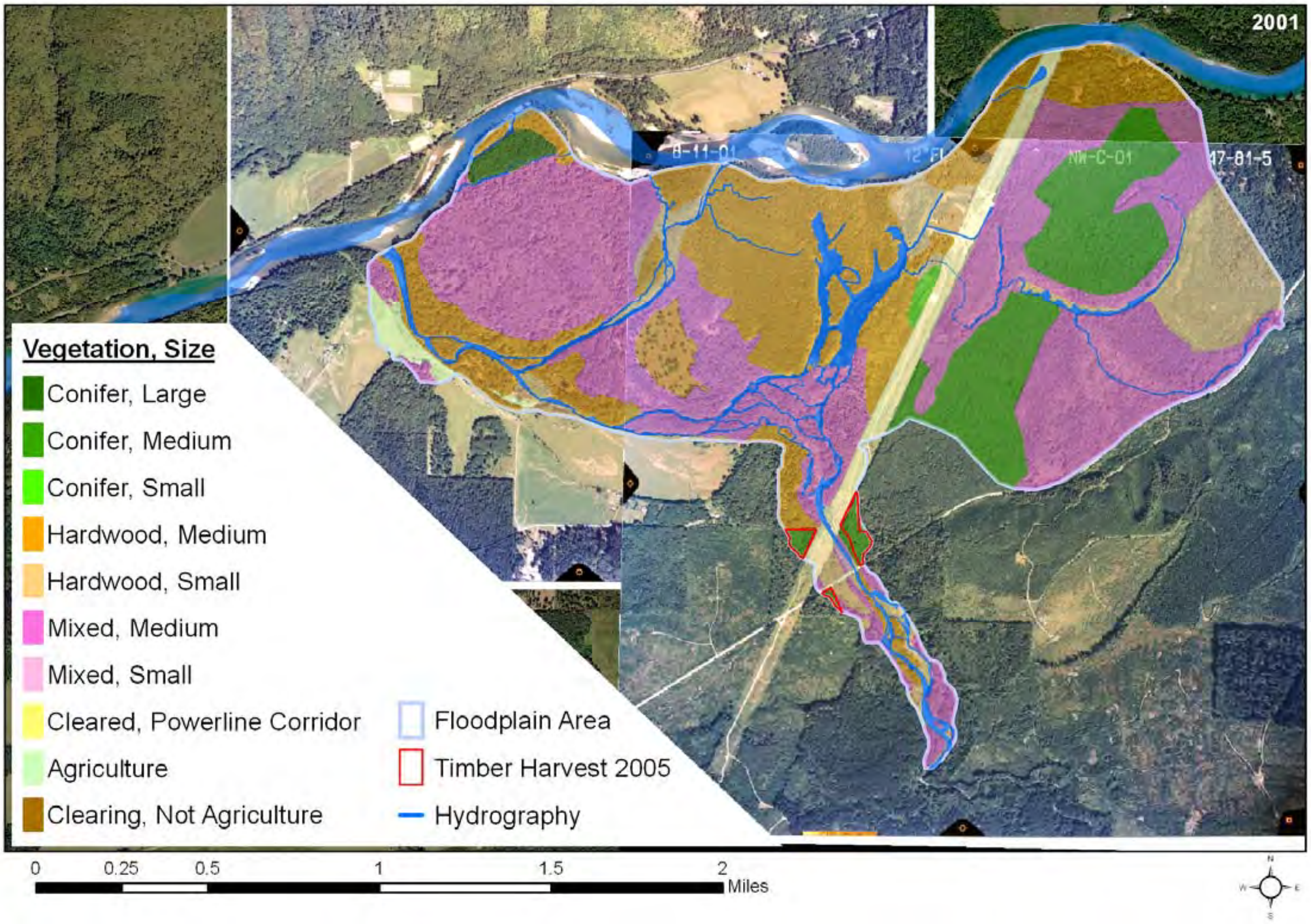


Figure 4-1 Overstory vegetation on the Illabot floodplain, mapped from stereopairs (2001), seen on map

Functioning riparian vegetation is important because it provides large woody debris (LWD) recruitment into streams and rivers (Skagit Watershed Council 1998). Large wood pieces provide important geomorphic and habitat function, and historically (pre-European) stream-side vegetation recruited into rivers and streams was composed of very large conifers and hardwoods (Collins and Sheikh 2002). Riparian conditions were summarized by Collins and Sheikh (2002) from an assessment of General Land Office surveys from the late 1800's, in which surveyors collected bearing tree information, which included tree size and species. They found that bearing tree records underrepresented the frequency counts of smaller species such as vine maple, but were an accurate way to estimate the historical basal area of floodplain forests. Historically, along the Upper Skagit and Lower Sauk floodplains, hardwood species, including bigleaf maple and red alder, were the most commonly counted tree species on forested floodplain and freshwater streamside (or riverine) sites, although these sites were dominated in basal area (75%+) by conifer species, specifically western red cedar and Douglas fir. The Illabot Creek floodplain study area follows this general trend although the sample size is much smaller and thus more easily influenced by the tree species encountered. Seventeen GLO survey points fall within the study area, and range from 1-4 trees recorded at each point for a total of 36 trees. On forested floodplain sites, hardwoods (mostly bigleaf maple) dominated in frequency (16 trees) while the 3 conifers encountered made up 83% of the basal area. Along forested riverine sites (which, in the GLO survey included only the Skagit River, and not Illabot Creek), only hardwoods were encountered (17 trees total). However as noted in the previous example had one large conifer been encountered it may have tipped the scales so that basal area was dominated by conifers. In this small sample, average diameter for conifers on forested floodplain sites within the Illabot study area was 24.5 inches while average diameter of hardwood trees was 6 inches.

Currently, forested buffers equal to or greater than 40 meters on either side of the stream are considered capable of producing 80% or more of the late seral recruitment of LWD into streams, and so streams that have a 40 meter or greater width of buffer are considered to be “functioning” habitat for LWD recruitment (Skagit Watershed Council 1998). Buffers that are 20-40 meters wide (capable of 50-80% potential recruitment) are considered to be “moderate” habitat and those with less than 20 meters of buffer are “impaired” (Skagit Watershed Council 1998).

Existing and Potential Function	**Dominant Vegetation**	**Size**
High	Conifer	Large
	Conifer	Medium
	Mixed	Medium
Medium	Conifer	Small
	Hardwood	Medium
	Mixed	Small
Low	Hardwood	Small
	Non-forested	N/A

Table 4-3 Vegetation categories summarized by existing and potential future function for a riparian buffer analysis

To identify areas within the Illabot floodplain lacking in riparian function, a 40-meter buffer was generated around the 2001 Illabot Creek hydrography and attributed with riparian condition types in a GIS (Figure 4-3, Table 4-5) and is summarized by habitat and reach in Table 4-4. Large conifers provide the largest LWD input for streams, more shade, and decay slower when submerged in water, and so riparian habitat within large and medium conifer dominated stands in this assessment was ranked as highest functioning habitat, followed by large and medium sized mixed stand types. Hardwoods have less habitat quality because they do not become as large as conifers, decay faster in water, and allow more light to infiltrate, and so were ranked as a lower functioning class depending on tree size. Forest stands of small sized hardwoods provide the lowest quality habitat for potential LWD recruitment. Riparian vegetation was ranked according to its existing habitat function with consideration of its potential future function (i.e. small conifer stands were ranked higher than small hardwood stands because in the future they will become large conifer stands, faster than small hardwood stands would). Table 4-3 lists dominant vegetation and size and their corresponding rank in the riparian buffer assessment. Cleared areas, including agricultural fields and the powerline corridor, provide no recruitment potential for LWD and therefore fall within lowest functioning riparian habitat types at this site. Table 4-4 summarizes riparian habitat quality along stream length (m) for the mainstem and floodplain habitats by reach (as described in sections 3.2.1 and 3.2.2). Riparian condition vary within reaches vary and across bank sides. When two habitats conditions occurred adjacent to each other on the same stream side, if the vegetated buffer was less than 20 m, it was assigned to the low habitat function. If the vegetated buffer was between 20-40 m wide, it was ranked down one class. If the vegetated buffer was 40 m wide with two class types, it was assigned the lower type or an average of the two types, depending on the combination. The stream lengths summarized in Table 4-4 were generated in the GIS and the lengths may not perfectly correspond with what was measured on the ground.

				Riparian Function Quality (length - m)		
	Reach	**Bank**	**Total length (m)**	**High**	**Medium**	**Low**
Mainstem Habitat	1	LB	1236.7	0.0	832.1	404.6
		RB	1236.7	0.0	1236.7	0.0
	2	LB	1997.9	1043.5	42.9	911.5
		RB	1997.9	1190.5	615.1	192.3
	3	LB	1474.7	1054.6	420.1	0.0
		RB	1474.7	1474.7	0.0	0.0
	4	LB	309.3	309.3	0.0	0.0
		RB	309.3	204.0	105.3	0.0
	5	LB	495.3	70.9	220.5	203.9
		RB	495.3	106.6	151.5	237.2
	6	LB	960.1	398.4	453.0	108.7
		RB	960.1	432.4	328.6	199.1
Floodplain Habitat	1	LB	582.7	523.2	59.5	0.0
		RB	582.7	523.2	59.5	0.0
	2	LB	293.2	140.3	152.9	0.0

		RB	293.2	0.0	293.2	0.0
	3	LB	971.8	536.7	196.8	238.3
		RB	971.8	226.8	497.8	247.3
	4	LB	292.0	0.0	183.1	108.9
		RB	292.0	119.5	0.0	172.6
	5	LB	455.4	0.0	320.9	134.5
		RB	455.4	0.0	0.0	455.4
	6	LB	538.7	0.0	538.7	0.0
		RB	538.7	0.0	538.7	0.0
	7	LB	599.2	0.0	599.2	0.0
		RB	599.2	0.0	599.2	0.0
	8	LB	641.8	0.0	641.8	0.0
		RB	641.8	0.0	641.8	0.0
	9	LB	930.0	301.5	562.1	66.4
		RB	930.0	0.0	930.0	0.0
	10	LB	325.7	0.0	0.0	325.7
		RB	325.7	0.0	0.0	325.7
	11	LB	406.1	160.8	85.5	159.8
		RB	406.1	0.0	0.0	406.1
	12A	LB	181.2	0.0	181.2	0.0
		RB	181.2	0.0	181.2	0.0
	12B	LB	137.7	0.0	0.0	137.7
		RB	137.7	0.0	137.7	0.0
	13	LB	1165.3	832.2	62.3	270.8
		RB	1165.3	832.2	156.9	176.2
	14	LB	1363.7	905.9	0.0	457.8
		RB	1363.7	1363.7	0.0	0.0
	15	LB	1270.3	1270.3	0.0	0.0
		RB	1270.3	1086.4	183.9	0.0

Table 4-4 Existing and potential future function summarized for stream lengths by reach

Areas of low functioning riparian habitat were found mostly along human-modified landscapes, including the agricultural fields along reaches 1 and 2, the powerline corridor crossing over reach 5, the constructed channels, and floodplain reach 13, the dike impacting reach 5, and a timber harvested unit adjacent to floodplain reach 14. Additional areas of low functioning habitat were found along floodplain habitats where small hardwood stands exist in a few areas. High functioning habitat was located around the braided channels of mainstem reaches 3 and 4, and portions of reach 6, and along floodplain habitat reaches 1, 3, 13, 14, and 15 within areas less frequently disturbed by human influences or areas that were replanted with conifers following timber harvest in decades past. Medium-functioning habitat was located along channels that typically had a hardwood-dominated component within the buffers. Figure 4-2 shows the areas of high, medium, and low-ranked habitat function.

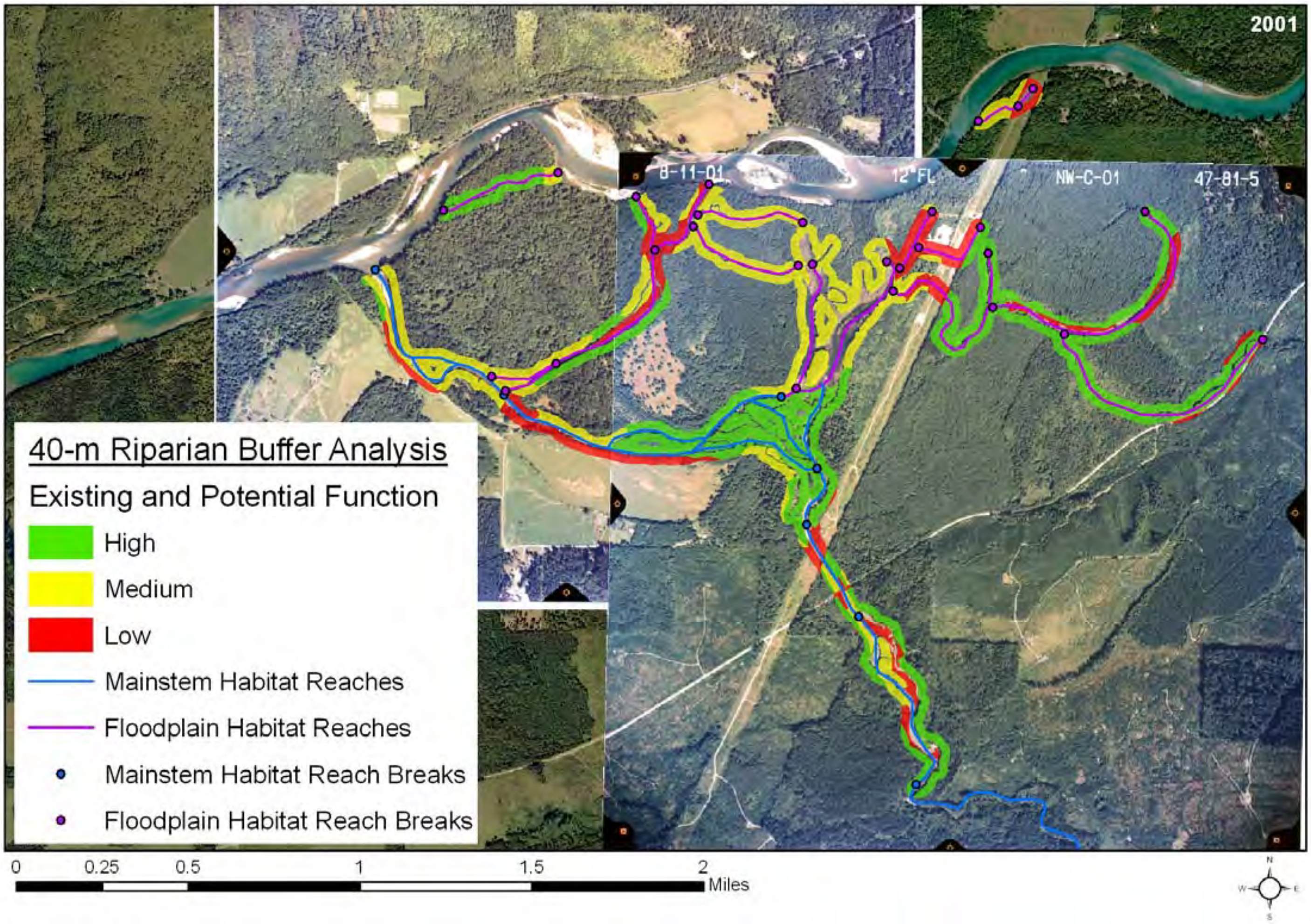


Figure 4-2 40-m riparian buffer analysis, summarized by high, medium, and low existing and potential habitat function

Move to alternatives section?........

	Function along stream length (%)		
Reaches	High	Medium	Low
Mainstem	48.5	34.0	17.5
Floodplain	43.4	38.4	18.1

Most of the riparian habitat falls within high and medium functioning habitat. Most of these areas are protected because they fall within a conservation land ownership, and riparian habitat conditions will only continue to improve. Areas of low functioning habitat are due mostly to either human impacts or stands of small hardwoods located on forested islands or streamside-adjacent. Within the 40-meter riparian buffer, 6.3% of the area is cleared due to human uses and these are the areas that should be targeted for restoration in the form of riparian planting. The agricultural fields adjacent to lower Illabot Creek (reaches 1 and 2) impact the riparian condition in three locations along a total stream length of over 1000 meters. Within the 40-meter buffer, 6.8 acres are cleared because of agriculture, leaving a thin buffer ranging from 6-20 m in width. Riparian condition is also impacted near the Rockport-Cascade bridge crossing by the dikes along the Illabot Creek channel and by the powerline corridor. The dikes eliminate LWD recruitment by preventing channel migration and separating larger forest away from the creek. Most of the riparian vegetation along the dikes consists of small and medium sized hardwoods and small and medium sized mixed species. A road runs along the top of the dike downstream of the bridge on the right bank of Illabot Creek, further impacting the width of the riparian buffer. Within the powerline corridor, vegetation is managed by Seattle City Light. Trees do not reach maturity and while some native shrub species are present, invasive species such as Scotch Broom are also quite abundant. The powerline corridor also crosses habitat in multiple areas, including O'Brien Creek and the constructed channels, limiting riparian vegetation along 1000 meters of stream.

Site ID	**Impairment**	**Length of Impaired Stream (m)**	**Acres Affected within Buffer**	**Prescription**
1	Agriculture	404.8	2.8	Plant/fence
2	Agriculture	23.8	0.1	Plant/fence
3	Agriculture	638.0	3.9	Plant/fence
4	Powerline Corridor	181.7	1.5	Invasive species control
5	Powerline Corridor	110.6	1.2	Invasive species control
6	Powerline Corridor	108.5	1.0	Invasive species control
7	Powerline Corridor	108.5	1.0	Invasive species control
8	Powerline Corridor	269.8	2.6	Invasive species control
9	Powerline Corridor	109.1	1.0	Invasive species control
10	Cleared/Gravel Spoils	136.2	1.3	Remove spoils/plant
11	Powerline Corridor	137.8	2.7	Invasive species control
D1	Dike	95.0		Remove dikes and plant
D2	Dike	464.6		Remove dikes and plant
D3	Dike	683.7		Remove dikes and plant

Table 4-5 Summary of impaired riparian habitat

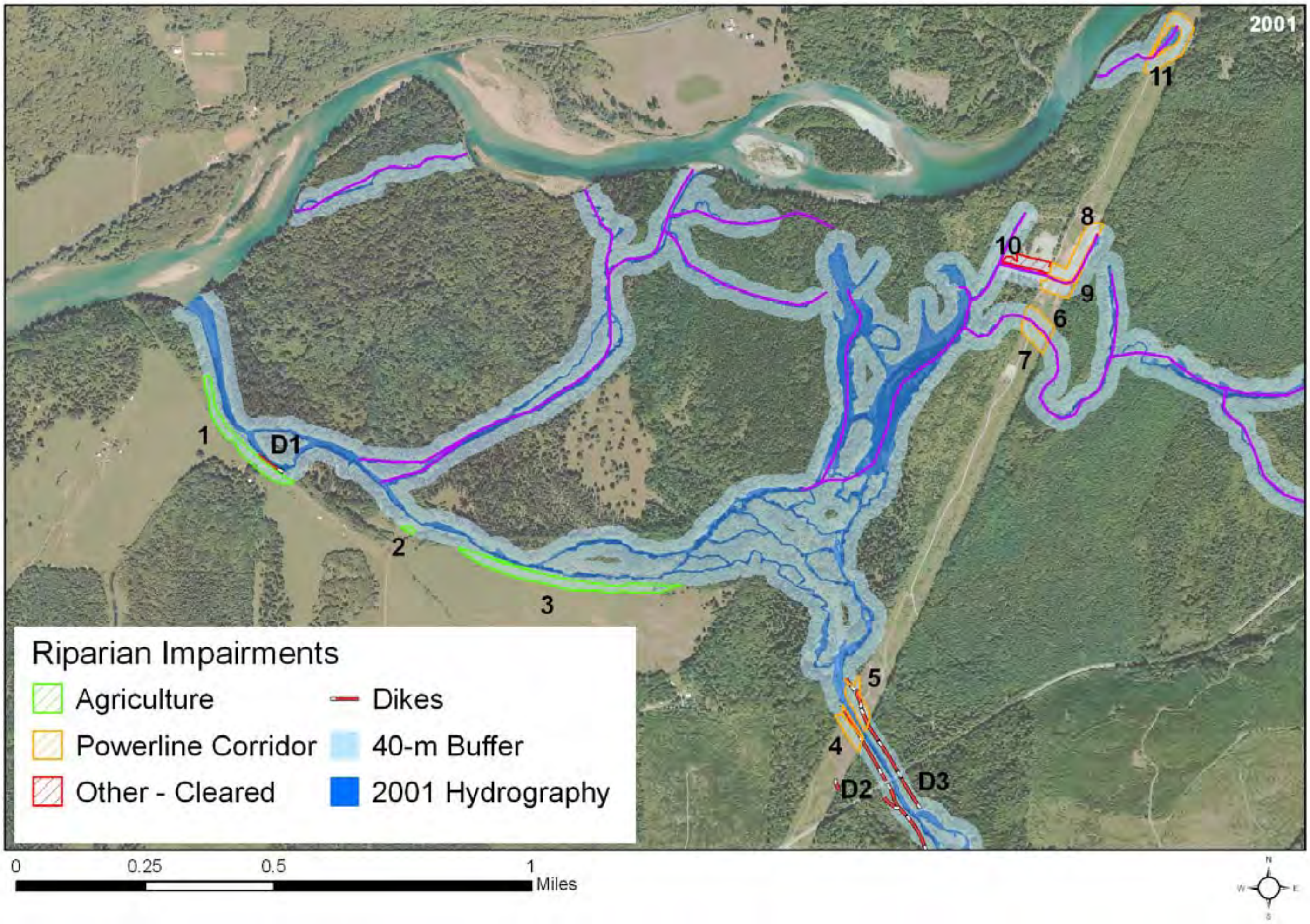


Figure 4-3 Examples of cleared areas within a 40-m riparian buffer providing low functioning habitat.

4.3 PASSAGE BARRIERS

A comprehensive inventory identified all culverts, bridges, and other stream crossing structures that block passage for anadromous fish in the Skagit River basin (SRSC unpublished data 2001). Washington Department of Fish and Wildlife (WDFW) methods (2000) were used to determine whether each crossing structure was a barrier to fish passage based on physical characteristics, including capacity compared to channel width, outfall drop, slope in the channel, and whether there is stream bed material inside the structure. According to the WDFW methods, crossing structures are identified as barriers if they block passage for any life stage during at least some flow conditions, so in some cases adult salmon may routinely pass through a crossing structure, but juveniles may have difficulty during higher flow conditions therefore it would be identified as a barrier.

There were no fish passage barriers identified on Illabot Creek in the inventory, but there were two barriers identified in the O'Brien Creek watershed, which is a tributary of Illabot Creek in the vicinity of Illabot Ponds that provides abundant rearing habitat for juvenile salmon. Crossing structures on O'Brien Creek are shown in Figure 4-4 and their physical characteristics are presented in Table 4-6.

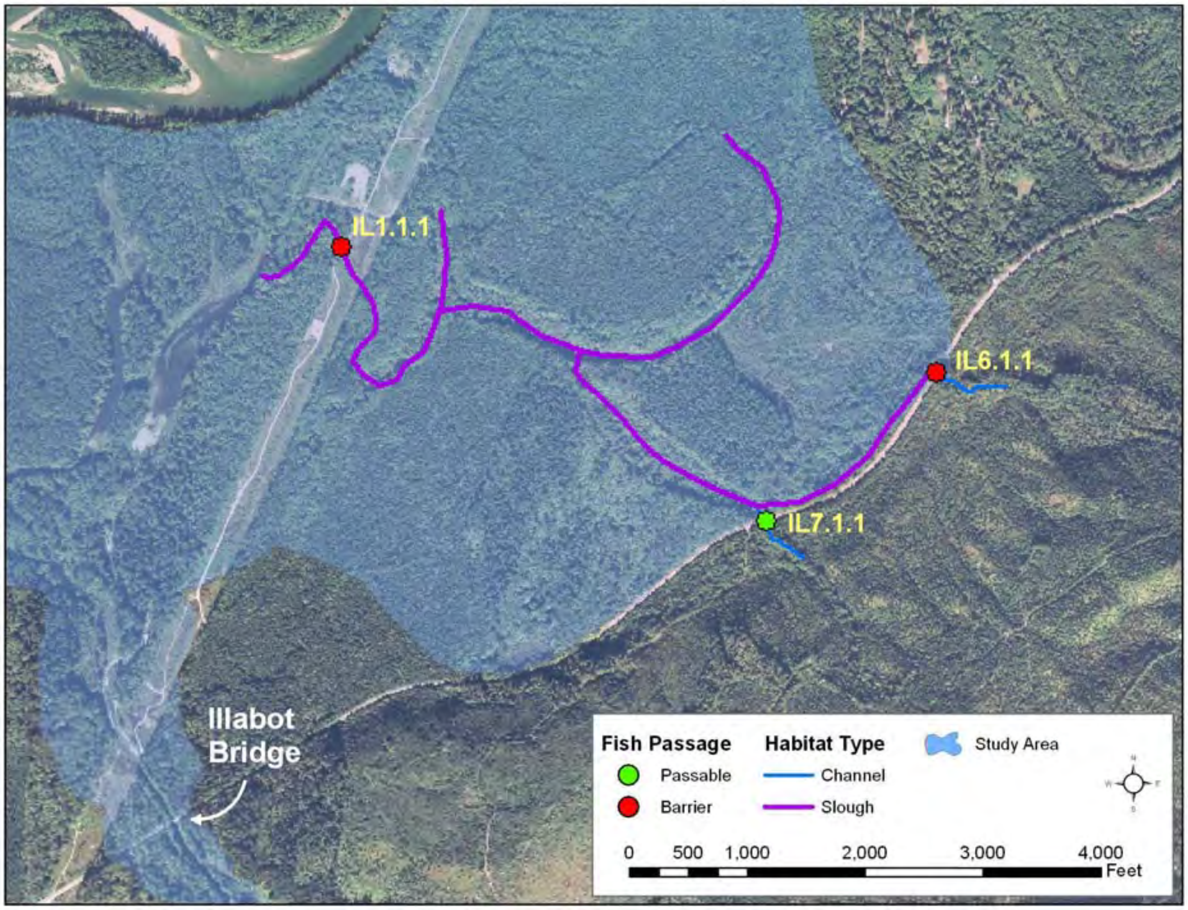


Figure 4-4. Map of culverts and fish passage barriers in O'Brien Creek complex

Site ID	Road	Structure	Channel Width (m)	Outfall Drop (m)	Bed Material?	Slope (%)	Barrier?
IL1.1.1	Powerline access road	48” culvert	10	0	NO	- 0.7	YES
IL7.1.1	Rockport-Cascade Road	36” culvert	1	0	YES	0	NO
IL6.1.1	Rockport-Cascade Road	68” X 94” squashed culvert	3	0	NO	4	YES

Table 4-6. Fish passage characteristics of stream crossing structures on O'brien Creek

Adult salmon are known to regularly pass upstream of both culverts that were identified as barriers, but the culverts are likely barriers to juvenile salmon. Coho salmon are the dominant species that would use the habitat upstream of IL1.1.1, although adult chum may use the very limited spawning areas and it is possible that juvenile Chinook may use the slough for rearing in small numbers (Eric Beamer, personal communication). In order to evaluate the benefit to salmon populations from fixing these passage barriers, habitat information was collected upstream of each culvert using a combination of field work, maps, and aerial photographs (Smith 2005 and SRSC, Unpublished Data). This included the wetted area of slough habitat in the winter, the length and gradient class of stream habitat, and the total area of spawning habitat available in those streams and sloughs. This information was then used to evaluate the total habitat that could be restored and also to identify whether this habitat was more likely to benefit adult or juvenile salmon.

Site ID	Passage	Wetted Area of Slough (m^2)	Length of Stream by Gradient Class (m)					Area of Spawning Habitat (m^2)
			< 1%	1-2%	2-4%	4-8%	>8%	
IL1.1.1*	Barrier	106,657	-	-	76	-	-	736
IL6.1.1	Barrier	-	-	-	-	99	100	0
IL7.1.1	Passable	-	-	-	27	38	73	26
Total upstream IL1.1.1	Barrier	106,657			103	137	173	762

*Habitat only reported to the next upstream culverts. Since IL6.1.1 (barrier) and IL7.1.1 (passable) are also upstream of IL1.1.1, the total amount of habitat upstream of IL1.1.1 is included in the last row of the table.

Table 4-7. Habitat available upstream of culverts in the O'brien Creek complex

The stream complex upstream of IL 1.1.1 includes over 100,000 square meters of low-gradient sloughs that could provide excellent rearing habitat in the winter for juvenile coho. There are only approximately 100 meters of stream length with low to moderate gradients and overall very limited adult spawning habitat in either the streams or sloughs. Though adult fish might pass through this culvert, there is very limited spawning habitat upstream, and it is unlikely that these fish can produce enough fry to seed all of the winter rearing habitat available. This means that addressing this passage barrier is likely to increase production by providing winter habitat for juvenile coho spawned in areas downstream of the barrier. Coho have been documented to move upstream to find winter rearing habitat, so it is likely that IL 1.1.1 is substantially reducing habitat value even if it only blocks juvenile salmon.

The habitat upstream of IL 6.1.1 is relatively limited due to the short length, the steep gradient of the stream, and the lack of available spawning habitat. While fixing this passage barrier may provide some benefits to fish, the benefits would be low relative to the expense. The best strategy here would be to make sure this culvert is upgraded to meet fish passage standards when it is replaced as part of routine road maintenance efforts.

4.4 HYDROMODIFICATIONS

In the 1940s, the Rockport-Cascade Road was not in its current location and the only major bridge across Illabot Creek was approximately 3,200 feet upstream from the current bridge. This bridge was likely destroyed in one of the large floods in 1949 or 1951. By 1963, Rockport-Cascade Road had been constructed with a small 40-ft crossing at Illabot Creek. In 1970/71 the road was upgraded and a new bridge was constructed over Illabot Creek. As part of this project, the Illabot Creek channel was straightened and relocated approximately 450 feet to the east. This new channel was diked and armored with rip-rap on both banks upstream and downstream of the bridge for approximately 1900 feet of length, completely channelizing the reach. Weirs were constructed in the new channel to maintain gradient through the reach. A small 36” culvert was installed in the road and a notch was constructed in the dike on the west side to allow water to flow through the historic channel during high water events, providing some flood relief and protection for the bridge. This extensive channel manipulation work was likely done to increase the efficiency of sediment transport and to protect the bridge and powerline towers from erosion, flooding, and channel migration.

The 1970 engineering plans provided by Skagit County and evidence from historic aerial photographs indicate that there have been a number of changes to the dike system since the original construction. In 1976, significant reinforcements were added to the dike both upstream and downstream of the bridge. The 1984 air photo shows that Illabot Creek migrated toward the east just downstream of the dike. This likely threatened the powerline tower in this area so the dike was extended and the channel returned to its previous location. In the early 1990s approximately 600 feet of the dike was washed away on the east side upstream from the bridge. This has not been repaired or replaced. In the flood of October 2003, water flowed into the historic channel and damaged the 36-

inch overflow culvert, which was replaced with another culvert of the same size shortly after. The following photographs and engineering designs illustrate some of the changes that have occurred to the Illabot Creek channel as a result of channelization, and a more detailed history is provided in Appendix A.

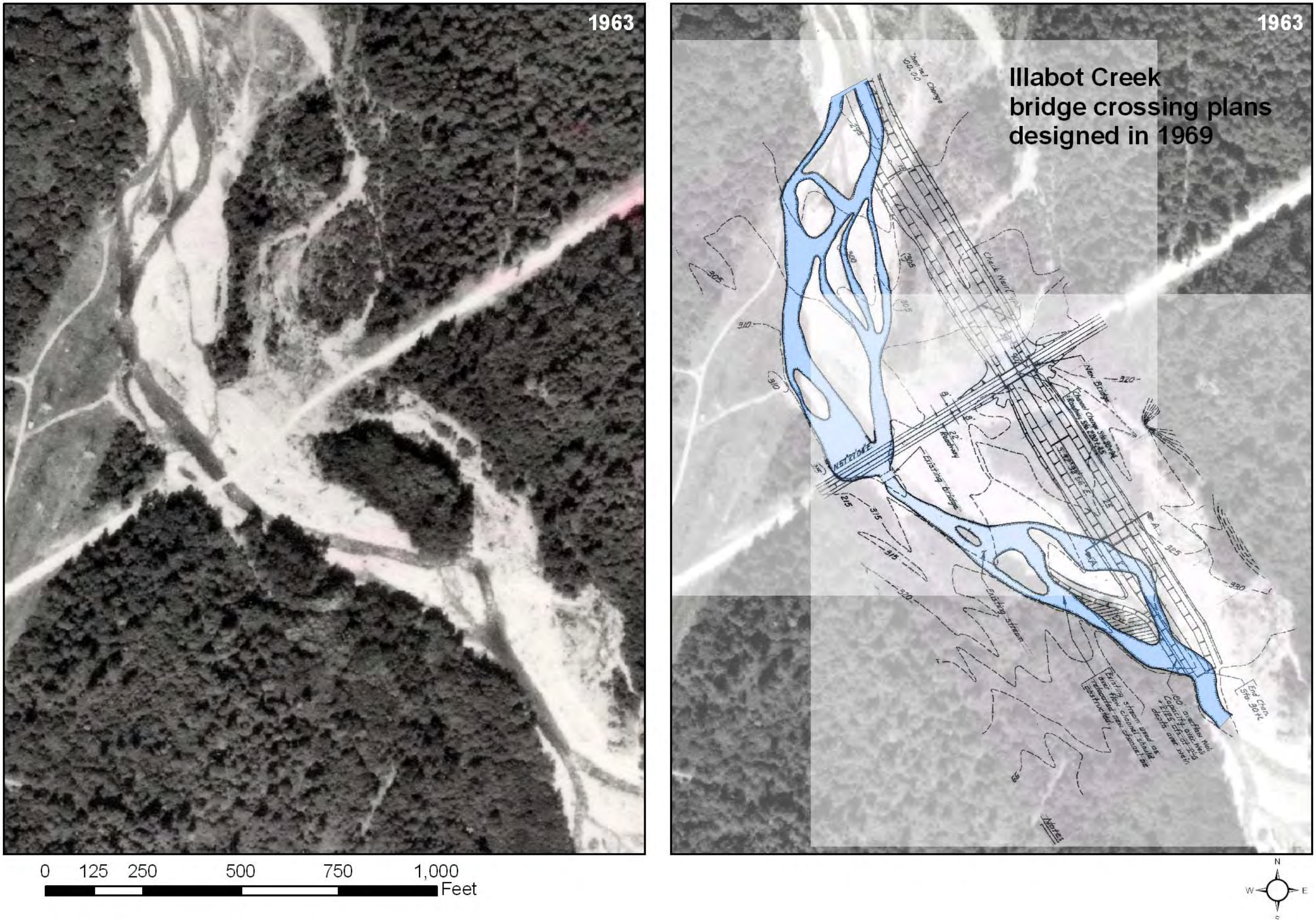


Figure 4-5 Engineering plans for Illabot Creek bridge crossing

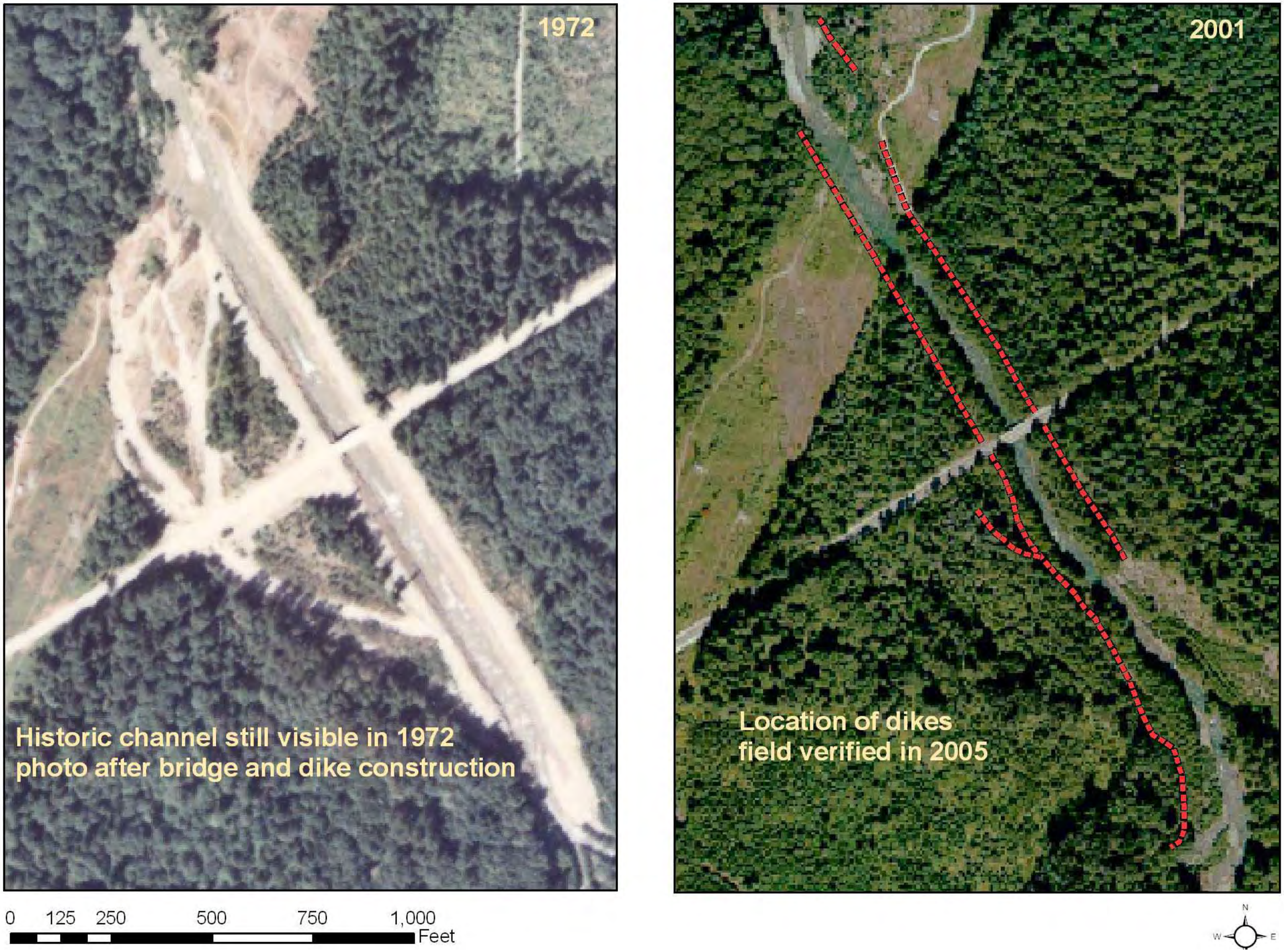


Figure 4-6 Completed bridge and dike construction and present-day dike locations

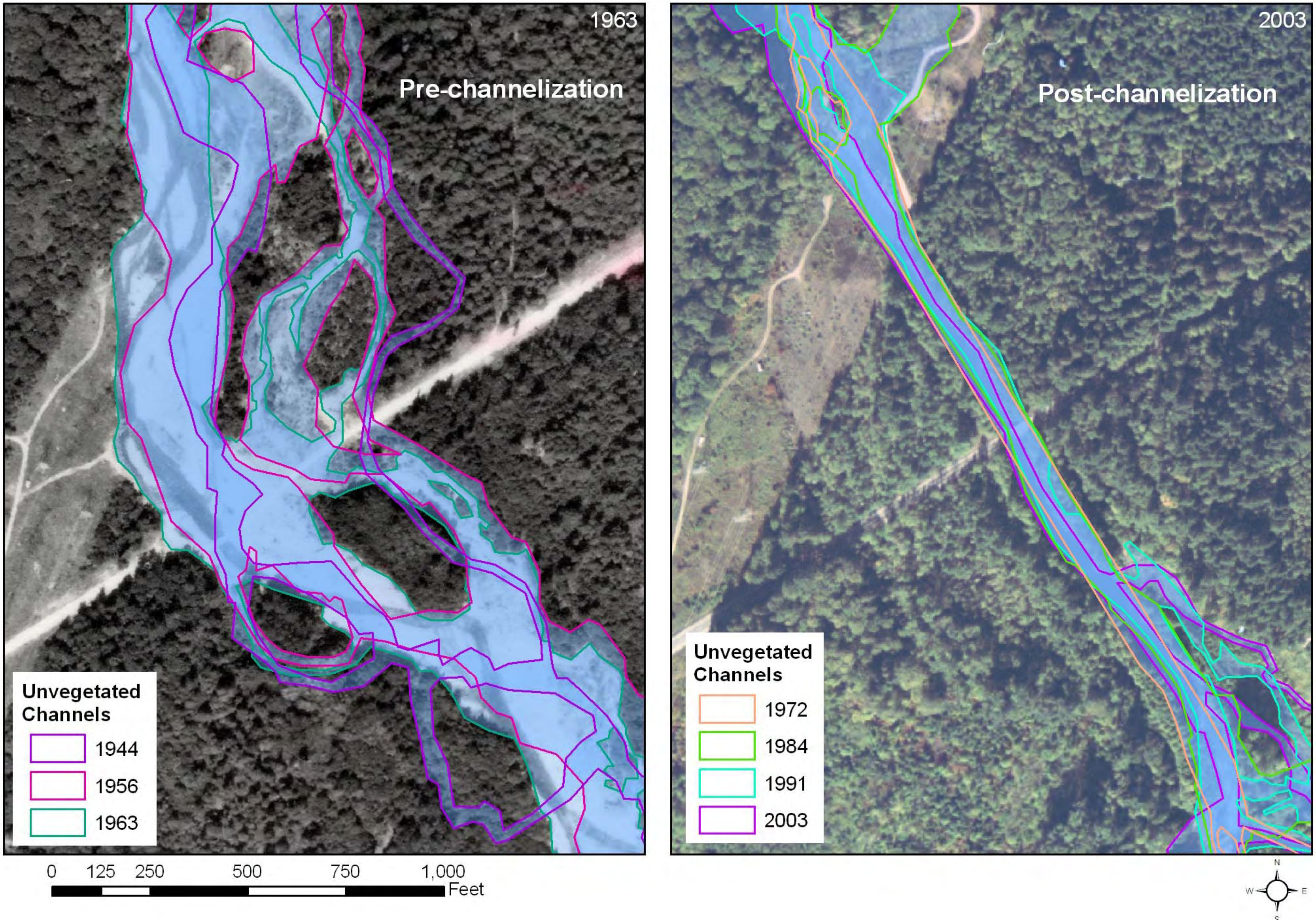


Figure 4-7 Channels digitized from historic air photos showing the effect of channelization on Illabot Creek

The extensive dike system has numerous negative impacts on habitat conditions for salmonids in this reach of Illabot Creek for the following reasons:

1) Riprap banks reduce edge habitat quality compared to natural banks. Beamer and Henderson (1998) measured fish abundance in natural and artificially modified edge habitats in the mainstem Skagit River and found that sub-yearling Chinook abundance averaged 5.4 times higher in wood cover than in rip-rap and that summer coho parr abundance averaged 3.7 times higher.
2) The diked and straightened channel has a steeper gradient, which increases bed scour and reduces lateral scour and pool formation. It also causes sediment to be transported to the reach downstream of the dikes that would otherwise deposit on the alluvial fan in this reach and increase habitat complexity. Beamer et al. (1998) concluded that these changes converted the channel from a forced pool:riffle type, which has high habitat value to a plane bed type, which has much lower habitat value.
3) Total habitat area in the current straightened, single-thread channel is much less than in the sinuous, multi-thread channel that existed prior to bridge and dike construction.
4) The dikes limit connectivity with the floodplain and alluvial fan. Historical photographs show that the channel migrated rather extensively in this reach prior to dike construction, but currently channel migration and associated habitat complexity are greatly reduced.
5) The dikes limit the recruitment of large woody debris (LWD), which provides numerous habitat benefits including forming pools in channels of this size and gradient. The impact on LWD recruitment is compounded because the engineered channel was likely cleaned of wood when the bridge and dikes were constructed. As a result, this reach has almost no LWD and the number of pools has been greatly reduced.

Beamer et al. (1998) quantified the effect of these impacts on fish use in the channelized reach. This study used habitat unit area collected in the field in 1992 and 1994, fish production models, and Chinook spawning surveys from the 1994 season and showed substantially lower fish use for this reach compared to adjacent reaches (Table 4-8).

Reach	**Length (m)**	**Total area (m^2)**	**1994 total LWD (pieces/ 100 m)**	**1994 Pool spacing (channel width/ pool)**	**Predicted coho density (parr/m^2)**	**Predicted potential coho parr**	**Observed Chinook spawning density (redds/ km)**
4	370	4,760	72.2	1.4	0.999	4,754	41
5	**510**	**6,924**	**5.7**	**10.0**	**0.483**	**3,346**	**6**
6	605	11,452	52.2	4.0	0.755	8,643	30

Table 4-8. Habitat conditions and fish use in Illabot Creek from Beamer et al. (1998). Reach 5 is the channelized reach, reach 4 is immediately downstream, and reach 6 is immediately upstream.

In order to estimate how much habitat has been lost due to bridge and dike construction, channel length, area, and bankfull width were measured and averaged for the channelized reach from aerial photographs for three year sets before the bridge and dikes were constructed (1943-63) and for eight year sets after (1972-2003). Information from LiDAR flown in 2005 was used to estimate the gradient for each of these photo years and averaged (Table 4-9). Although unvegetated area is not a direct measure of habitat conditions because it is larger than the wetted area and can be influenced by sediment supply conditions and flooding, it provides an indicator of how much channel area was available before bridge construction. The results show that on average, before channelization, the channel length was almost 400 feet longer, total area was three times greater, and gradient was 0.18% less. This indicates that total habitat area available was greatly reduced with bridge and dike construction.

Channel Condition	**Year sets**	**Unvegetated channel area (ft^2)**	**Average bankfull width (ft)**	**Channel Length (ft)**	**Gradient (measured from LiDAR)**
Channelized	1972-2003	187,283	91.2	2053	1.50%
Unchannelized	1943-63	613,755	251.1	2444	1.32%

Table 4-9. Average characteristics of channelized reach before and after bridge construction, measured from historical aerial photographs.

According to bridge design drawings dated 1969, the channelized reach is approximately 1,900 feet long with a gradient of 2.0% and the natural channel was 2,350 feet long and a gradient of 1.5%. These numbers are slightly different than information taken from photographs and LiDAR, but they show the same magnitude of change. These bridge design drawings also include a map of the wetted area of the channel in 1969. While it is only one look at historic habitat conditions, it can be compared with wetted channel conditions on the 2001 air photograph to get a sense for how much the wetted channel was altered through bridge and dike construction (Table 4-10).

Channel Condition	**Year sets**	**Wetted area (ft^2)**	**Wetted Length (ft)**	**Wetted Width (ft)**
Channelized	2001 air photo	84,223	2,064	41
Unchannelized	1969 engineering drawings	198,613	2,464	81

Table 4-10. Comparison of wetted channel characteristics for channelized reach using 2001 air photo and 1969 engineering survey

In order to quantify the impacts to fish production from the dikes and bridge, the methods in Beamer et al. (1998) and Reeves et al. (1989) were used to estimate fish use in a fully restored channel to compare with the existing diked channel in the channelized reach (Table 4-11).

Habitat Type	**Fish/m^2**
Pools	1.7
Glides	0.9
Riffles	0.4
Beaver ponds	1.3
Side channels	1.7

Table 4-11. Fish density estimates for coho parr in summer habitat from Reeves et al. (1989)

Unfortunately, it is not possible to measure habitat conditions in the field for a future restored channel. However, estimates were made of habitat conditions based on the wetted channel characteristics taken from the 1969 engineering survey. Obviously wetted channel conditions can vary with different flows and in different years, and the 1969 channel was somewhat modified by road construction, but this still provides the best reasonable estimate of what channel conditions may look like under a restored condition. In order to use the Reeves et al. (1989) coho model, it is necessary to know the total area in each of several habitat unit types. In order to estimate pool area, the average % pool estimate from the two adjacent channel reaches were averaged to give 30% pool estimate. This number was multiplied by the wetted channel area from the engineering drawings to estimate how much pool area would be present in a restored channel, and it was assumed the remainder of the area was riffle habitat (which has the lowest density of coho use). These numbers were used to calculate potential coho parr for a restored channel with the Reeves et al. (1989) model (Table 4-12).

Reach	**Total area**	**% pool**	**Pool area (m^2)**	**Glide area (m^2)**	**Riffle area (m^2)**	**Potential coho parr**	**Coho density (fish/m^2)**
4	4,760	46%	2,192	0	2,568	4,754	0.999
5	6,924	6%	443	0	6,481	3,346	0.483
6	11,452	24%	2,714	1,069	7,669	8,644	0.755
5 restored	**18,452**	**30%**	**5,536**	**0**	**12,916**	**14,577**	**0.790**

Table 4-12 Coho parr density, current and estimated for a restored channel

With these methods, a restored channel would produce 14,577 coho in summer habitat, with a density of 0.790 fish/m^2 compared to the channelized conditions, which produce 3,346 coho with a density of 0.483 fish/m^2. This suggests almost a five-fold increase in coho parr use in a restored channel.

The Chinook spawning survey data from 1994 can also be used to estimate adult Chinook use in a restored channel (Table 4-13). The average Chinook redd density for reaches 4 and 6 was 35.5 redds/km, whereas the density in the channelized reach was 6 redds/km for a total of 3 Chinook redds. With a restored reach length of 744 m and using the average of 35.5 redds/km from the two adjacent reaches, the estimate of Chinook spawners would be 26 redds. Obviously spawner use is highly variable year-to-year, but this indicates that spawner use in a restored channel would be substantially higher than in the current diked channel.

Reach	**Reach length (m)**	**Chinook redd density (spawners/km)**	**Total Chinook redds**
4	370	41	15
5	510	6	3
6	605	30	18
5 restored	**744**	**35.5**	**26**

Table 4-13. Chinook spawner density and reach totals from 1994, reported in Beamer et al. (1998), used to estimate Chinook use in a restored channel

5 HABITAT PROTECTION AND RESTORATION PRESCRIPTIONS

The previous section described habitat conditions and identified several habitat impacts on the Illabot Creek alluvial fan and floodplain area. The purpose of this section is to identify specific prescriptions that should be followed to continue protection efforts for high quality habitats and to restore habitat conditions where they have been degraded. The specific areas of sediment, riparian vegetation, fish passage barriers, hydromodifications, and protection are discussed in detail below.

5.1 SEDIMENT

In the past Illabot Creek has had a management-related increase in sediment supply as a result of timber harvest and road construction. However, these sediment increases are not as large as in some other similar watersheds in the Skagit River basin. In addition, the majority of management-related sediment impacts in Illabot Creek have been addressed through road decommissioning and upgrade treatments and through limitations in timber harvest through management changes on Forest Service lands and acquisition by Seattle City Light. So there is very little to be done to address sediment issues in the Illabot Creek watershed, except for the possibility of further acquisition of private timber lands or ensuring the limited existing roads used for timber harvest on private lands are properly evaluated and treated to address sediment concerns through the Road Maintenance and Abandonment Plan process. In addition, further monitoring work should be conducted over time to ensure that past road treatments continue to be effective.

5.2 RIPARIAN AND FLOODPLAIN VEGETATION

Much of the Illabot Creek floodplain area is in conservation status and is currently forested with a mix of conifers and hardwoods. While many of these stands have average diameters of < 20” DBH and some are composed of small hardwoods, it is anticipated that they will grow and mature over time to provide functional large woody debris. However, there are a few specific locations where planting cleared or farmed land with native tree species out to 40 meters from existing channels and constructing fences to prevent cattle access would improve riparian conditions. There are approximately 6.8 acres in agricultural production along 3,900 feet of stream length that should be fenced and planted along the lower portion of Illabot Creek. The cost for this should be less than $30,000 and could be subsidized by existing programs such as the Conservation Reserve Enhancement Program (CREP).

In addition, there are approximately 900 feet of stream bank length flowing through the power line corridor that have poor riparian condition. Unfortunately, there is little that can be done about this because tall trees cannot be grown under powerlines. But it would be worthwhile to eliminate non-native species in these areas and plant native vegetation that does not grow taller than 20 feet. This impact could be partially mitigated by installing large woody debris in the affected channels.

Lastly, there is approximately 2,660 feet of bank length that have limited riparian function because of the presence of dikes. The best treatment for these areas would be to remove the dikes and replant native vegetation along disturbed ground, which is discussed in the hydromodification section.

5.3 PASSAGE BARRIERS

The culvert at the O'Brien Creek crossing on the powerline access road creates a passage barrier for juvenile salmon. There are over 100,000 square meters of low-gradient juvenile rearing habitat in O'Brien Creek upstream of this barrier and a very limited amount of spawning habitat. Upgrading this culvert to meet fish passage standards would allow juvenile salmon to move upstream from other areas to access the abundant rearing habitat.

The channel width at the existing culvert is 33 feet, and upstream of the culvert the channel width averages 40 to 50 feet, so a bridge with a 50 foot span will be needed to adequately pass flow and provide fish passage. This bridge will need to be load-rated to HS-20 highway standard, which will support the weight of powerline maintenance vehicles and fire trucks. A budget for this project is provided in Table 5-1.

Task	**Cost**
Purchase steel girder bridge with corrugated metal deck, 50' long X 14' wide, load-rated to 80,000 lbs (estimate from Big R Manufacturing)	$55,000
Contract for culvert removal, bridge installation, and gravel road surface on top of deck	$22,000
Engineering, permits, project administration, and associated indirect expenses	$25,000
Total Cost Estimate	**$102,000**

Table 5-1. Budget for replacing O'Brien Creek fish passage barrier with a bridge

5.4 HYDROMODIFICATIONS

The impacts from the bridge and dikes on Illabot Creek associated with the Rockport-Cascade Road are by far the greatest impact to habitat conditions and provide the best opportunity for habitat restoration and increases in fish production. Three alternatives are considered for improving habitat conditions associated with the bridge crossing: 1) permanently close the Rockport-Cascade Road, relocate Rockport-Cascade Road to its original (1940's) alignment and upstream Illabot stream crossing, or completely trestle the floodplain, 2) add an additional bridge span at the historic (1963) crossing and remove the rip-rap dikes, and 3) leave the current bridge in place, but remove dike material downstream of the bridge on the west side of Illabot Creek. In all alternatives, additional work should be considered to protect powerline towers from channel erosion, and to place large woody debris in the restored channel and floodplain.

5.4.1 Alternative 1. Close, Relocate, or Construct a Trestle on Rockport-Cascade Road

The most effective alternatives for restoring full function to the Illabot Creek alluvial fan are to remove or relocate the portion of Rockport-Cascade Road that crosses the fan or construct a trestle across the fan (Figure 5-1). In addition, the existing bridge and the dikes along Illabot Creek would be removed, additional protection would be provided for two sets of powerline towers, Illabot Creek would be restored to its historic channel, and large woody debris structures would be placed in the restored channel. All of these alternatives would provide habitat conditions equivalent to those existing prior to road and bridge construction by allowing Illabot Creek to migrate naturally along its alluvial fan as it did historically with virtually no risk of future erosion or channel movement affecting the road or bridge crossing. However, these kinds of alternatives would be expensive and would likely be opposed by nearby property owners if they increased driving times for locations accessed by the existing road. For these reasons, they were not examined in careful detail, but are described conceptually below.

Closing Rockport-Cascade Road on either side of Illabot Creek would involve removing approximately 1670 feet of road. This would not eliminate access to any location, but would increase driving times for certain routes. Driving distance to the bridge crossing from Rockport is 5.8 miles by following the route south on Hwy 530 and then east on Rockport-Cascade Road. If the bridge were closed, driving distance to go further east on Highway 20, cross over the Skagit River in Marblemount and then drive west along Rockport-Cascade Road would be 15.1 miles, an additional distance of 9.3 miles. This would be an effective and cost-efficient way to restore habitat conditions in Illabot Creek, however closing the road is likely to be unpopular with nearby private property owners that would face increased driving times.

Relocating Rockport-Cascade Road would involve constructing a new bridge approximately 3,200 feet upstream from the existing bridge, in the vicinity of the bridge that crossed Illabot Creek sometime prior to 1956 (Figure 5-2). In order to prevent impacts to the channel and avoid problems with sediment and erosion that likely affected the previous bridge in this location; the new bridge would need to span the entire alluvial fan, which is only 250 feet wide at this location. Approximately 1670 feet of highway would be removed and a minimum of two miles of new highway would need to be constructed. Although much of this construction would be on a pre-existing grade, it would need to climb approximately 300 vertical feet and then back down again to connect with the existing highway.

Constructing a trestle would involve elevating Rockport-Cascade Road and constructing a highway trestle across the entire width of the Illabot Creek alluvial fan. This trestle would essentially be a long-spanning bridge supported with numerous piling structures. It would be designed so that the Illabot Creek channel could migrate unobstructed along the entire alluvial fan. In order to accommodate all channel locations observed throughout the photo record (1943-2003), this trestle would need to be at least 800 feet in length.

Alternative	**Costs**	**Increased drive times**
Close road	Reasonable, likely < $1 million	10-15 minutes or less for most locations
Relocate road	Estimated at $7-$10 million	5 minutes or less for most locations.
Install trestle	Estimated at $6-$8 million	No change

Table 5-2 Summary of Alternative 1

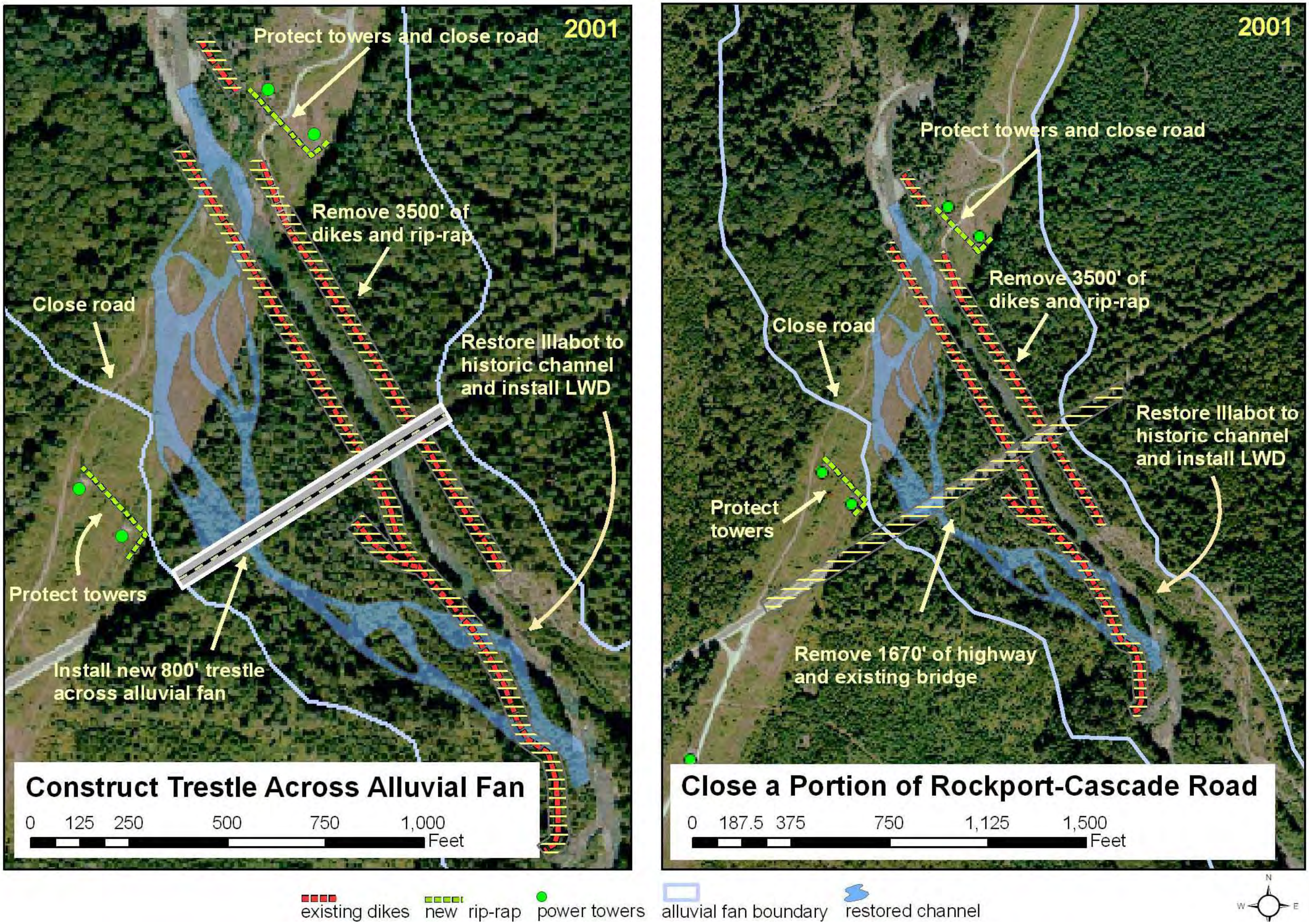


Figure 5-1 Maps detailing Alternative 1, constructing a trestle across the fan and closing Rockport-Cascade Road

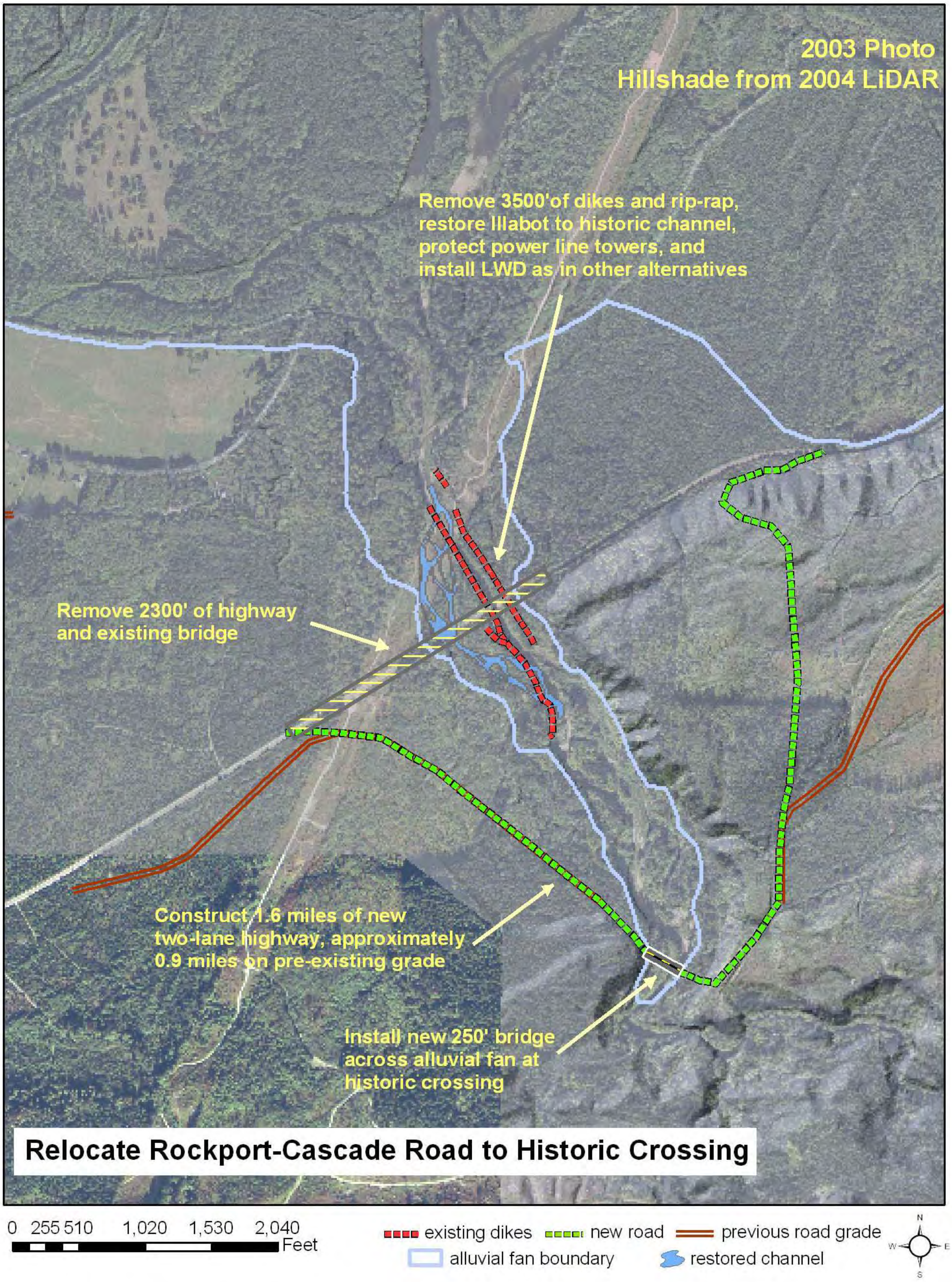


Figure 5-2 Map of Alternative 1, relocating Rockport-Cascade Road

5.4.2 Alternative 2 - Restore Illabot Creek to Historic Channel

This alternative involves removing existing dikes upstream and downstream of the current bridge and relocating Illabot Creek to the channel it occupied during the 1944-1963 photo sets (Figure 5-4). A new large-span bridge would be constructed so that Illabot Creek would pass under Rockport-Cascade Road in this historic channel footprint. The existing bridge, possible lengthened, would remain in place to provide an opportunity for flood relief and future channel migration. Accumulations of logs and large woody debris will be installed in the restored channel to improve habitat conditions and provide some erosion protection for bridges and powerline towers. Small portions of the dike may be left in place and some additional armoring installed in key locations to fully protect both bridges and the powerline towers.

This alternative would improve habitat conditions by increasing the total area and quality of channel habitat, improving edge habitat by removing rip-rap from the channel, restore connectivity to the riparian area and floodplain, and restore the potential for some natural channel migration along the alluvial fan. The riparian area will not be fully restored because a portion of the channel will flow through the powerline corridor, which cannot have large trees that may damage the power lines. This limitation will be mitigated to some extent through the installation of large woody debris structures in the restored channel.

It is possible that removing dikes and rip-rap downstream of the existing bridge could increase the threat of erosion to powerline towers on either side of Illabot Creek in the future. The towers to the east of the creek are currently heavily armored with large rock and the armoring will be left in place under any restoration scenario. The towers to the west of the creek are located on a terrace that is approximately 8 feet higher than the elevation of the historic channel and may also be armored. A hydraulic analysis should be completed to evaluate to what extent restoration could increase erosion risks to these towers and to develop and evaluate additional protection measures if needed. Protection measures could include adding additional rock armoring and sheet piling to either or both sets of towers, installing log structures in the channel to reduce or prevent erosion in key locations, placing towers on concrete pilings that extend well below the depth of potential scour, or relocating the power towers. These measures should be developed and evaluated with input from Seattle City Light engineers.

In order to evaluate the feasibility of restoration, elevation data were taken along four cross-sections of the alluvial fan from LiDAR that was flown for the site in 2005 (Figure 5-5). LiDAR does not penetrate water, so the elevation for the existing channel is for the water surface, not the bed elevation. It was assumed that the water depth was approximately 1.5 feet on average at the time of the flight, which was used to calculate bed elevation (Table 5-3). Using these data, the historic channel bed elevation varies from approximately 5 feet higher than the current channel bed elevation at the most upstream transect to 0.5 feet higher at the downstream transect and averages a little greater than 2 feet higher overall.

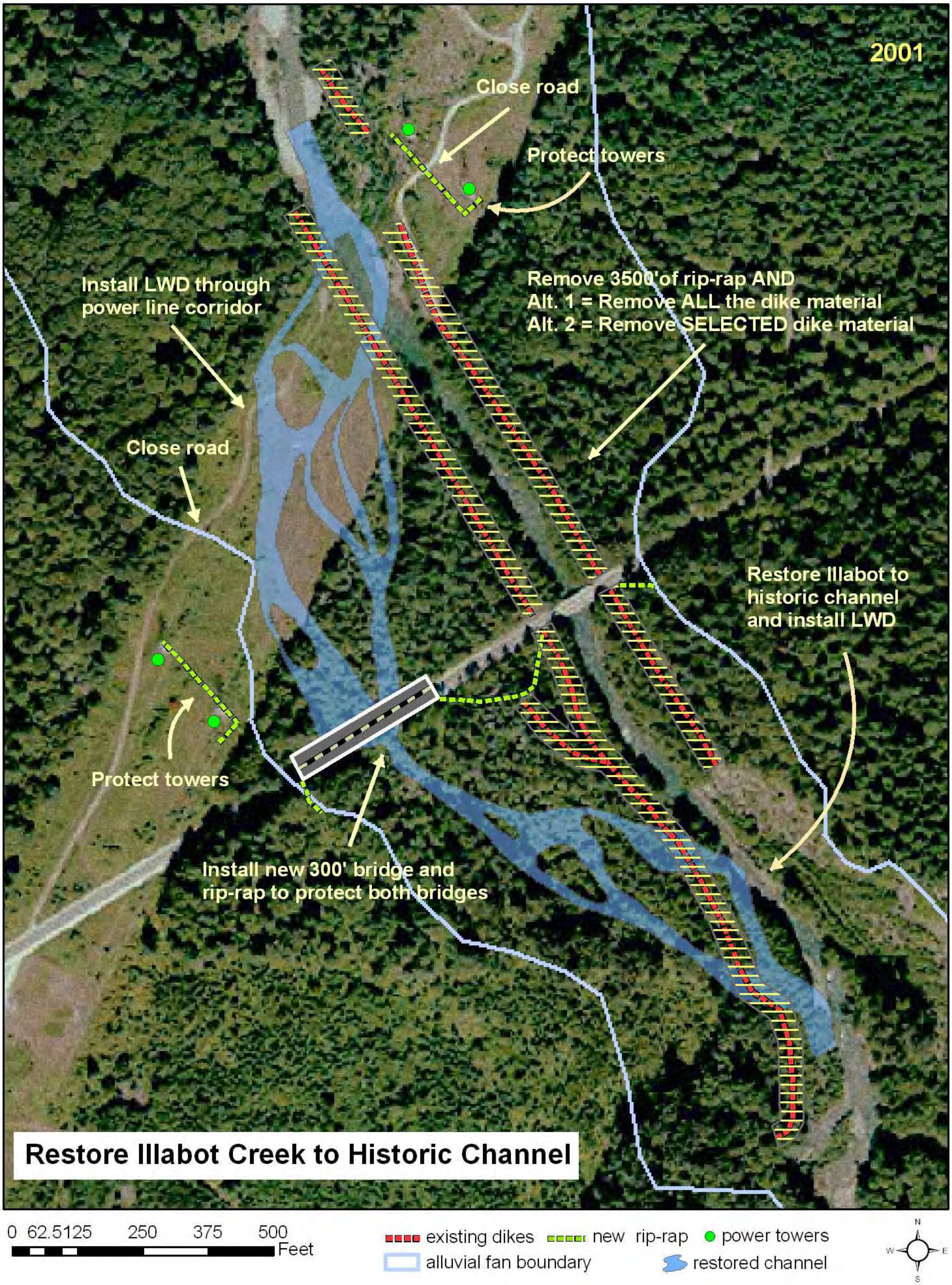


Figure 5-3. Conceptual drawing for restoring Illabot Creek to historic channel

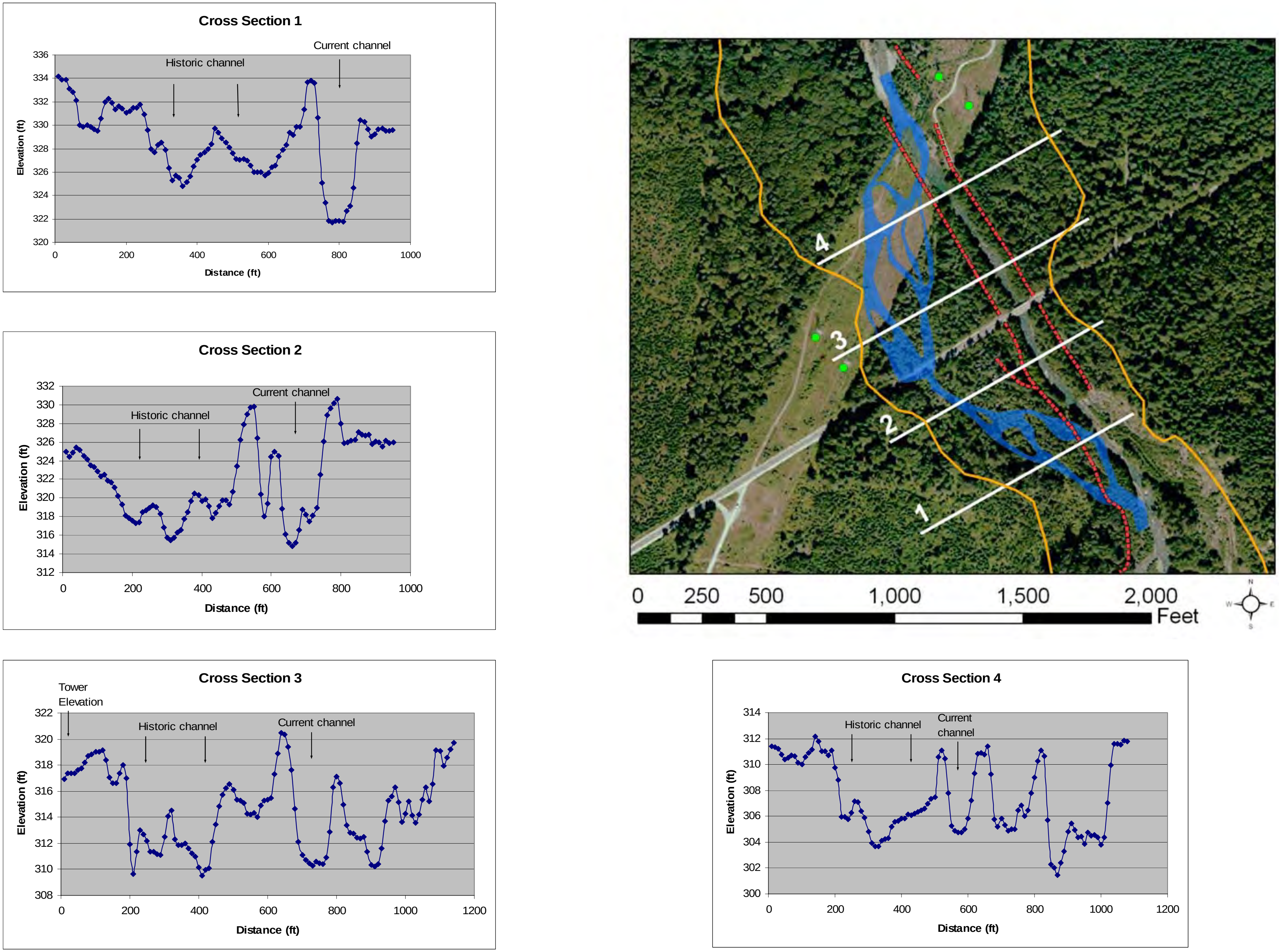


Figure 5-4. Cross section data taken from LiDAR flown in 2005. Shows elevation differences between current channel elevation and elevation in historic channel that will be restored. Current channel elevation is to the WATER SURFACE.

Cross-section	**Elevation historic channel above water surface in current channel (ft)**	**Water depth (ft)**	**Elevation in historic channel above bed surface in current channel (ft)**
1	3.5	1.5	5
2	0.5	1.5	2
3	-0.5	1.5	1
4	-1.0	1.5	0.5
Average			2.125

Table 5-3. Elevation differences between current channel and historic channel, measured from LiDAR using an assumed average water depth of 1.5 feet in the current channel.

The historic channel has a greater elevation than the current channel. The lower elevation in the current channel likely resulted either from excavation when the current channel was originally constructed or erosion of the bed that has occurred as a result of the channel being straightened and artificially confined. The original engineering designs called for weirs in the constructed channel to maintain a constant gradient, which likely have prevented more substantial bed erosion than what has occurred.

These elevation differences create significant design issues for restoring flow to the historic channel. It will be necessary to either 1) excavate the historic channel to an elevation where flows will naturally choose that pathway (remove 15,000 – 30,000 cubic yards of material), or 2) install log weirs or other structures to trap sediment and raise the elevation of the existing channel, and to directly divert flow into the historic channel.

The new bridge will need a span large enough to accommodate high flows, sediment deposition, and channel migration. A large span will also reduce the need for extensive armoring to protect the new bridge from erosion. Historical photographs show that the largest channel width was no greater than 250 feet, so a 300 foot bridge should be long enough to accommodate most channel configurations. The bridge will also need to be somewhat elevated to account for the fact that there may be greater sediment deposition in this reach after the dikes are removed and a lower gradient channel restored. This is not expected to be a large problem because the restored channel will have a gradient between 1.3% - 1.5% and will continue to have the capacity to transport sediment out of the reach. This should be evaluated in a hydraulic analysis to ensure proper size for the bridge.

Before implementing a restoration project, a detailed hydraulic analysis needs to be completed to accomplish the following objectives:

1) Evaluate the functionality of existing bridge if dikes are removed, both for conveying flow and allowing for channel migration and habitat formation.

2) Determine if some portions of the dike can be left in place to conserve costs while still maintaining the full habitat benefits of the project.

3) Compare the effectiveness and costs for various options to restore flow to the historic channel: channel excavation, installation of log weirs, or a combination of the two.

4) Evaluate the potential erosion risks to the power towers on both sides of Illabot Creek and to the existing and newly constructed bridges. Identify protection measures that are needed to protect this infrastructure in a way that maximizes habitat benefits. Also determine the elevation needed to ensure that future sediment deposition will not create a problem for the new bridge.

5) Locate and design log accumulations in restored channel to improve habitat conditions and to help address identified erosion risks in the restored channel.

5.4.3 Alternative 3 - Remove Dike Downstream of Bridge

This alternative would involve no change to the existing bridge crossing, but would remove the dike on the west side of Illabot Creek downstream of the bridge (Figure 5-5). This would be more cost-efficient and would provide some of the habitat benefits outlined for the previous alternative, but would not accomplish full restoration. This alternative could be completed in a staged effort to achieve some benefits before implementing one of the more ambitious alternatives.

This alternative would include installing large woody debris structures in the existing channel and along the adjacent floodplain to improve habitat conditions and encourage the channel to migrate toward the west.

The powerline towers on the west side of the creek would still be armored to protect them against erosion, but the risk is very low that Illabot Creek could make a sharp enough turn once passing through the bridge to pose any threat to the powerline towers.

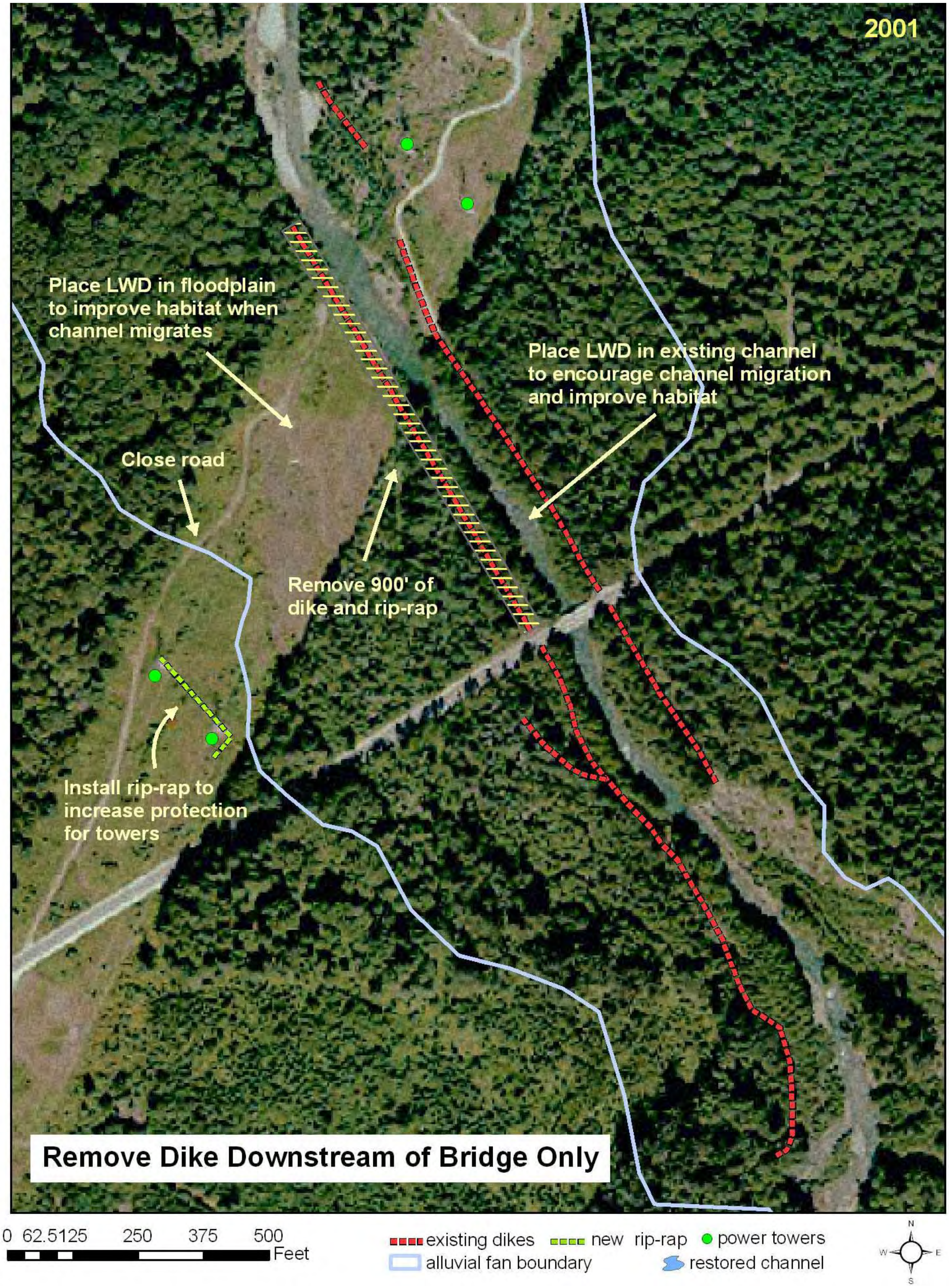


Figure 5-5 Alternative 3, removing dike downstream of bridge

5.4.4 Costs

In order to determine how much material is currently present in each section of dike, the existing width and average height above grade were measured with a tape at regular intervals. Total volume was calculated by multiplying average height * average width * length (Table 5-4). This is not as accurate as an engineering survey, but provides a reasonable general estimate.

Location in relation to bridge	**Average height (ft)**	**Average width (ft)**	**Length (ft)**	**Volume (cubic yards)**
Right bank downstream	5.1	40.1	784	5,922
Right bank upstream	6.7	55.3	401	5,479
Right bank dike nr power tower	5.2	8.2	155	247
Left bank downstream	6.8	42.2	903	9,537
Left bank upstream	5.8	33.8	1,065	7,674
Left bank upstream, spur dike	6.9	45.9	208	2,438
Total				**31,296**

Table 5-4 Estimate of dike volumes

To calculate costs, the values from Table 5-4 were used to estimate total volume of material that needs to be moved for each alternative. Effective volume was calculated as 15% greater than measured volume to account for expansion as the compacted dike material is excavated and moved. This effective volume was assumed to be composed of roughly 25% large, heavy riprap and 75% loose fill material cobble-sized and smaller based on field observations and review of the original engineering plans. A larger percentage of heavy riprap was assumed for alternative 2, because some of the loose fill material will be left on site but almost all the heavy riprap will be removed (Table 5-5).

Alt.	**Volume (cy)**	**Effective Volume (cy)**	**Amount Heavy Riprap (cy)**	**Amount Loose Material (cy)**	**Cost for Riprap at $11.33/cy**	**Cost for Loose material at $4.93/cy**	**Total Cost**	**Total days**
1	31,296	35,991	8,998	26,993	$101,973	$133,165	**$235,138**	61
2	21,458	24,677	8,637	16,040	$97,886	$79,131	**$177,017**	46
3	9,537	10,967	2,742	8,225	$31,073	$40,578	**$71,651**	19

Table 5-5 Riprap removal cost estimates

In addition to dike removal, there are other activities that need to be included with each alternative and approximate costs are provided in Table 5-6. Costs for equipment mobilization, contingency, and project oversight are included. $10,000 is included for additional powerline tower protection. The budget for dike removal includes transporting and placing heavy riprap in the vicinity of the powerline towers, but there may be additional construction activities that will be needed to insure adequate protection of the towers. As those plans are more clearly developed, this cost will be refined.

In alternatives one and two, there will also be costs for excavation in the historic channel and/or construction of log weirs in the present channel with the purpose of creating sufficient elevation in the present channel for water to flow down the historic channel. Installation of large woody debris is for habitat purposes and will be installed in the historic channel prior to flow diversion. These features will be designed by a hydraulic engineer (costs for consultant also included) and costs will be more refined at that stage.

Activity	**Alt. 1**	**Alt. 2**	**Alt. 3**
Mobilization	$5,000	$5,000	$5,000
Dike removal, transport riprap to power towers, transport remaining material to waste site, shape waste site	$235,139	$177,017	$71,651
Additional work for power tower protection	$10,000	$10,000	$10,000
Excavation and/or weir construction to restore flow to historic channel	$45,000	$45,000	$0
Installation of LWD in historic channel	$35,000	$35,000	$20,000
Contingency @ 15%	$49,521	$40,803	$15,998
Hydraulic analysis and engineering design work	$25,000	$25,000	$0
Project oversight by project manager	$12,297	$9,172	$5,621
Subtotal	**$411,956**	**$341,991**	**$123,270**
Cost for new 250’ bridge	$2,000,000	$2,000,000	$0
Grand Total	**$2,411,956**	**$2,341,991**	**$123,270**

Table 5-6 Estimated costs for each alternative

5.5 PROTECTION

Much of the land in the Illabot Creek watershed has been acquired for conservation purposes or is occupied by a land use that is likely to have limited habitat impacts (such as the land managed by the Forest Service). However, because of the important fish production value of Illabot Creek and because such a large investment has already been made in protection and habitat restoration, it makes sense to continue pursuing these kinds of protection efforts. It would be worthwhile to continue pursuing conservation easements or fee simple ownership for the few remaining private lands in the floodplain and alluvial fan of Illabot Creek.

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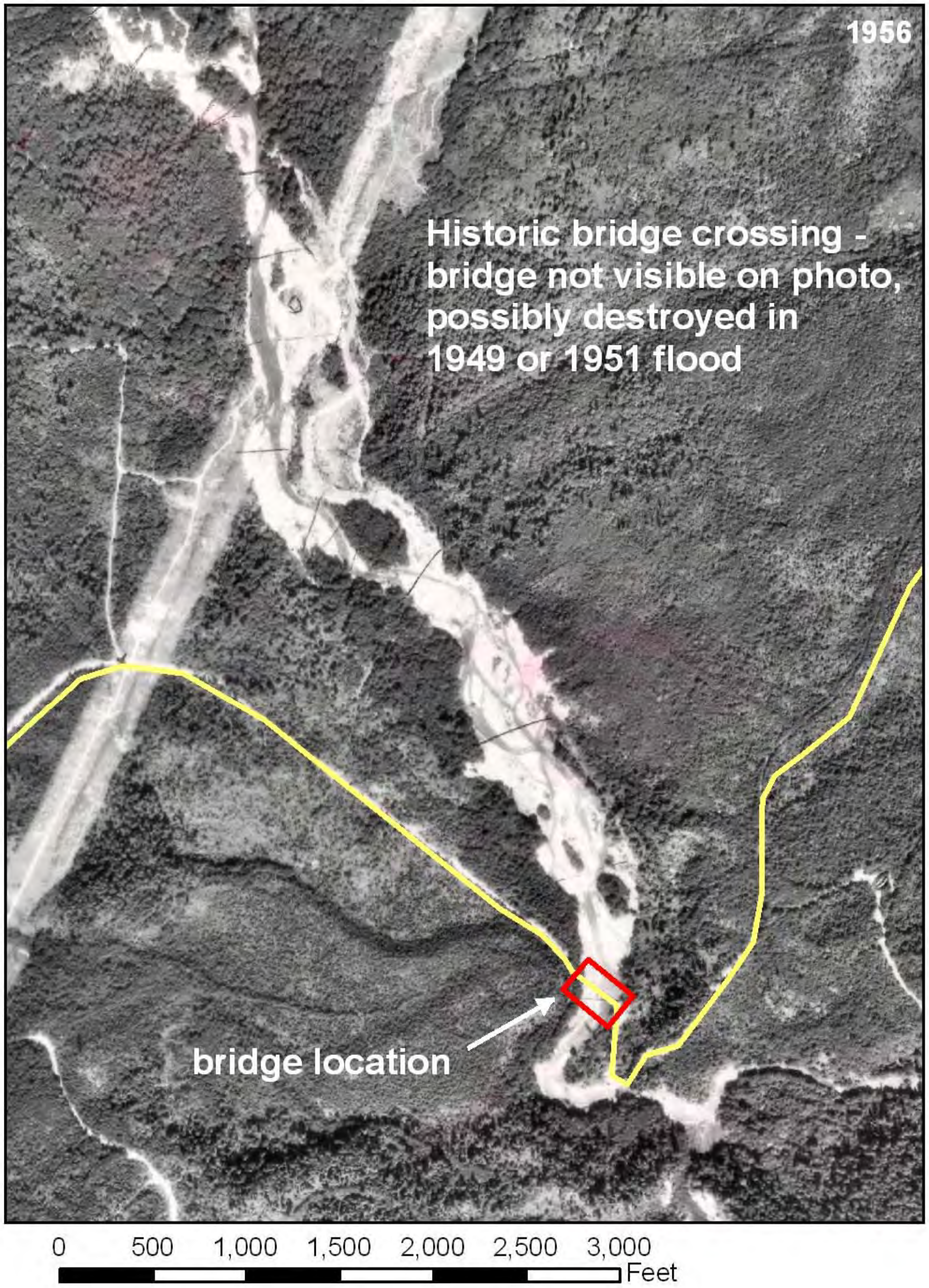
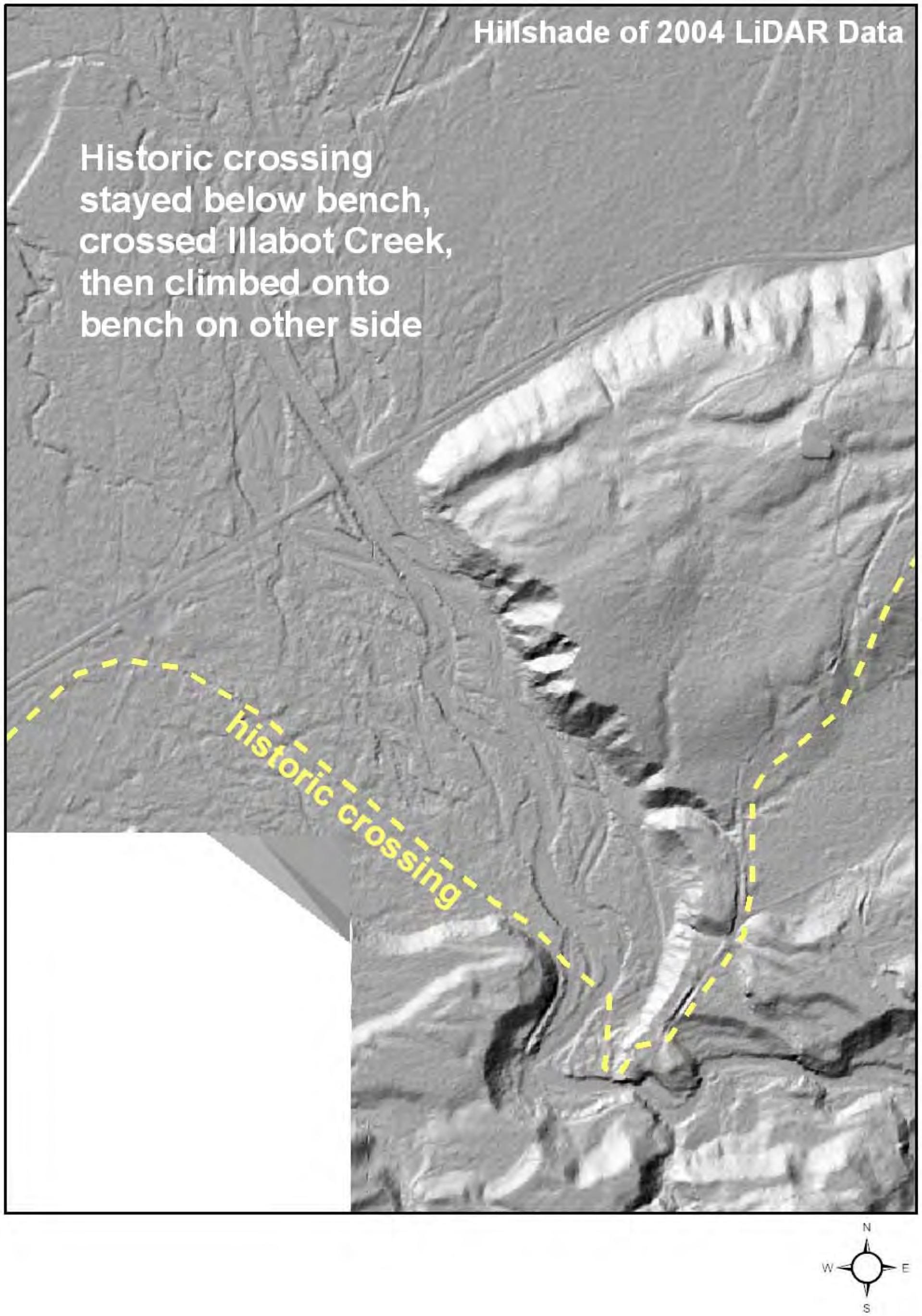
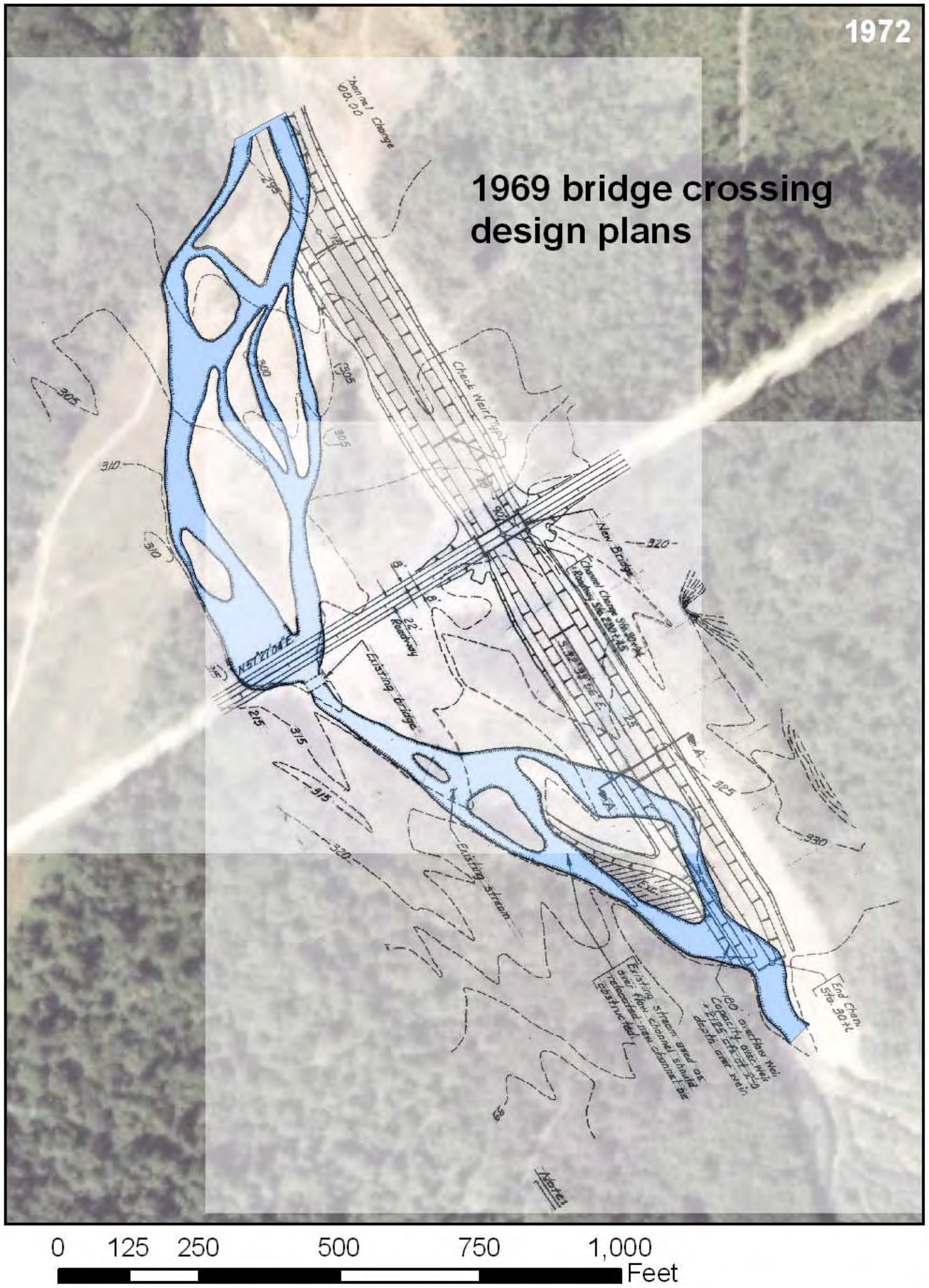
Appendix A. Bridge History


1956
Historic bridge crossing - bridge not visible on photo, possibly destroyed in 1949 or 1951 flood
bridge location
0
500
1,000
1,500
2,000
2,500
3,000
Feet

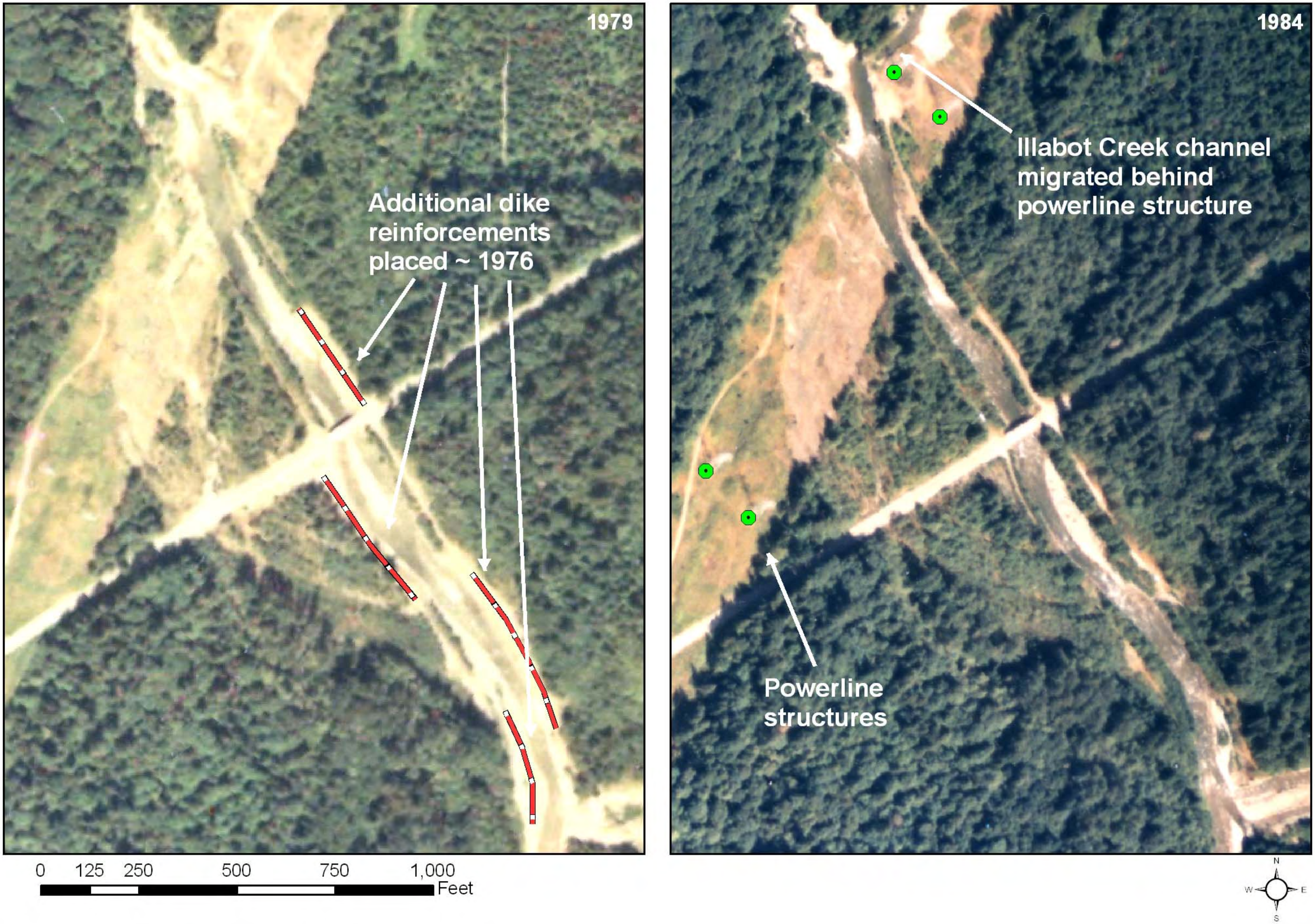

Hillshade of 2004 LiDAR Data
Historic crossing stayed below bench, crossed Illabot Creek, then climbed onto bench on other side
historic crossing
N
W
E
S

bridge crossing installed and new road built between 1956 & 1963;
no bank protection visible on photo

1963 bridge location -
bridge length was 40 ft across, according to engineering drawings


1972
1969 bridge crossing design plans
Check Weir
New Bridge
Existing Bridge
Existing stream
Roadway
305
310
315
320
325
330
0
125
250
500
750
1,000
Feet

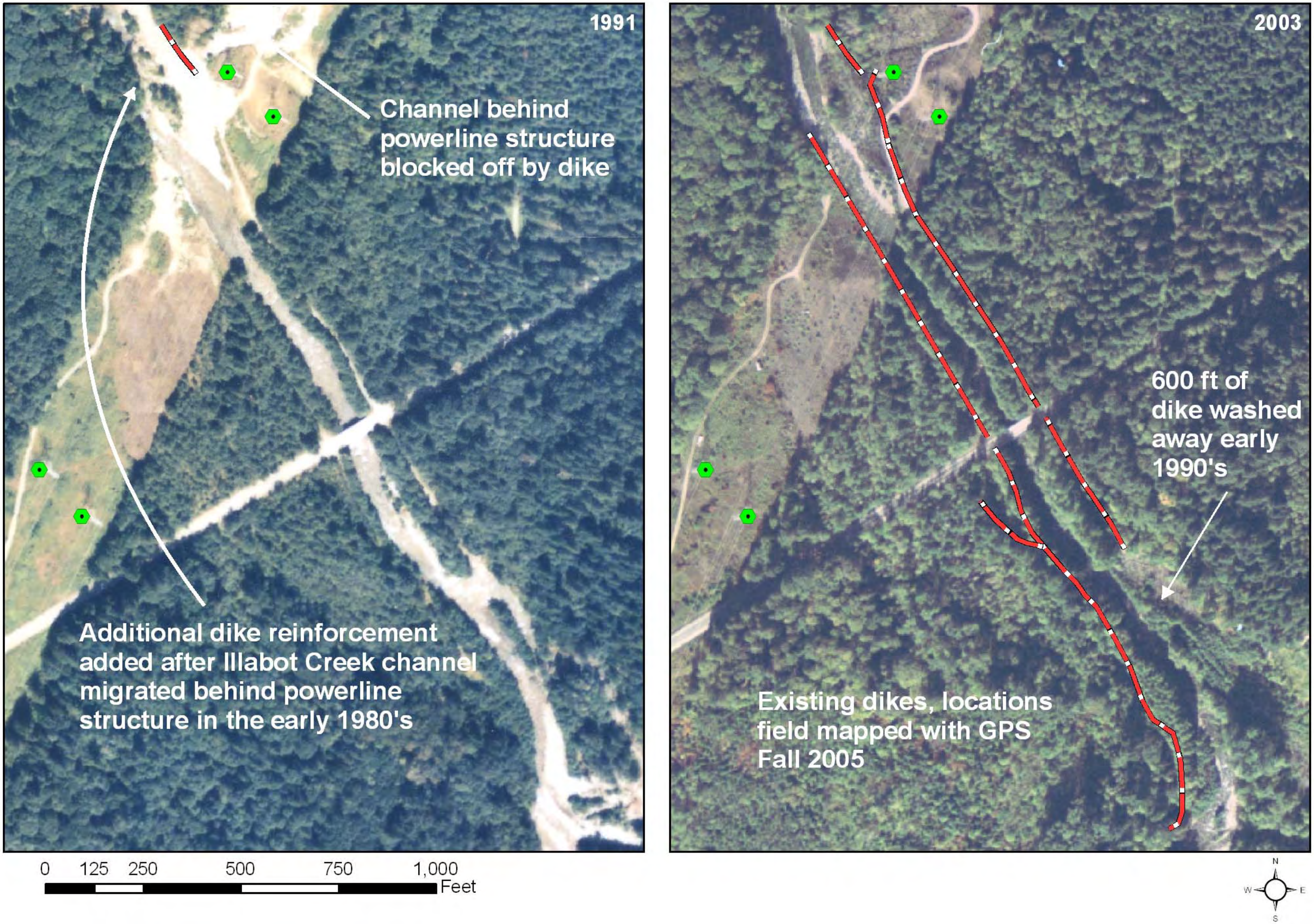

1972
Illabot Creek bridge crossing and dikes completed
Old Illabot Channel still visible
N
W
E
S



Additional dike reinforcements placed ~ 1976

Illabot Creek channel migrated behind powerline structure

Powerline structures


1991
Channel behind powerline structure blocked off by dike
Additional dike reinforcement added after Illabot Creek channel migrated behind powerline structure in the early 1980's
2003
600 ft of dike washed away early 1990's
Existing dikes, locations field mapped with GPS Fall 2005
0
125
250
500
750
1,000
Feet
N
W
E
S