2.3.4 Aquatic Habitat/Riparian Corridors

2.3.4 AQUATIC HABITAT/RIPARIAN CORRIDORS

The purpose of the Stillaguamish CWD includes rehabilitation of stream and riparian corridors for hydraulics, aesthetics, and fisheries benefits. (See Snohomish County Code 25A.05.010 (3)). This section addresses aquatic habitat and riparian corridors. In the first part of this section, the discussion will be on aquatic habitat, which provides the spawning, rearing, and migratory habitat for fish species. Riparian corridors, which are the structure within which aquatic habitats exist and provides habitat for terrestrial species, will be discussed in the second part of this section.

2.3.4.1 Aquatic Habitat

2.3.4.1A Status of Aquatic Habitat in the Clean Water District

Aquatic habitat is found throughout the rivers, streams, and wetlands of the Clean Water District. Rivers are spawning, migration, and juvenile and subadult rearing habitat for Chinook salmon, chum salmon, sockeye salmon, coho salmon, pink salmon, steelhead, cutthroat trout, bull trout and numerous other fish species. Streams provide some spawning habitat for salmon species, spawning for all other fish species, rearing habitat for juvenile salmon, and transitory habitat of all types for numerous other fish species. Wetlands provide rearing habitat for coho and other salmonids (Crance 1988). All these aquatic environments provide habitat for numerous other wildlife species, from eagles to flies. Domestic species such as horses, cows, sheep, dogs, and humans also use these waterbodies, if accessible.

Figure 2.3.4-1 shows stream locations, and subbasins where habitat surveys have been conducted by Surface Water Management in the Stillaguamish Watershed. As noted in Section 2.3.2 Streams, the Mainstem, North Fork and South Fork have approximately 104 miles of combined length within the Clean Water District, and approximately 122 miles of combined length within the entire Stillaguamish Watershed. There are about 570 miles of Types 1, 2 and 3 streams in the Clean Water District. In the Stillaguamish Watershed, which extends beyond the Clean Water District, there are about 724 miles of Types 1, 2 and 3 streams in the North Fork basin, 253 miles in the South Fork basin, and in the Mainstem basin, about 192 miles.

Table 2.3.4-1 summarizes existing wetlands in the Stillaguamish Watershed, tabulated by subbasin from a 1997 database by the Department of Ecology. Some of the subbasin names differ from those used by Surface Water Management. This constitutes the current status of the wetland resources in the Clean Water District. Local research on historical conditions in the river valleys and estuary of the Stillaguamish has shown that the current wetland acreage of all types is greatly reduced compared to historical conditions (Washington Conservation Commission 1999, Collins 1997, Collins and Sheikh 2003, Stillaguamish Implementation Review Committee 2005).

As noted in Section 2.3.2 Streams, upper reaches of the North and South Forks are under the direct jurisdiction of the U.S. Forest Service (USFS) and State Department of Natural Resources, and slightly over half of the watershed and the stream and river system contained within, is under direct federal or state control. Of the remaining lands and stream and river system, the unin-corporated areas are under the jurisdiction of Snohomish County. This includes most of the

Table 2.3.4-1 Wetlands in Stillaguamish Watershed

	Wetland Category (Area in Acres) *								
Subbasin	DC	DO	EF	FR	PO	RC	RO	SL	Total
Canyon Creek	64	448		188	138		164		1,001
Cavanaugh	41	1,223		2,715			33		4,012
Church Creek	58	399	338			1	82		878
Deer Creek	59	121		19			60		259
Ebey Hill	31	286				9	249		575
French Boulder	77	20			2	9	75		183
Hazel	2	30					68		99
Jim Creek	9	1,352		250	36		73		1,720
Jordan	54	386			14	1	189		644
Pilchuck Creek, Lower	100	310					161		571
Portage Creek	26	520		96		4	315		960
Silverton	9	196					85		290
Stillaguamish, Lower	83	985	616	497		18	313	0	2,512
Stilly, Upper NF	0	18					3		21
Stimson Hill	15	136					162		313
Grand Total	628	6,428	954	3,763	190	42	2,032	0	14,037

***DO=Depressional Open (has outlet); DC=Depressional Closed (no outlet); EF=Estuarine Fringe; FR=Fringe (permanent depth > 2 meters); PO=Peat Open; RC=Riverine Closed; RO=Riverine Open; SL=Slope.**
Source: Gersib 1997

lower Mainstem and its tributaries, lower portions of the North and South forks and their tributaries, and streams in the coastal areas. Depending on the location and nature of development, development in streams and wetlands are also under the permit jurisdiction of the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the State Department of Fish and Wildlife, and the State Department of Ecology.

Aquatic Habitat Functions

The physical functions of aquatic habitat include spawning and rearing space for fish species through the interaction of bank materials, flow, complexity from accumulations of large woody debris, riparian vegetation and their roots, and introduced sediment. This interplay in a particular stream reach creates rich, complex, and spatially diverse habitat (i.e., living conditions) or relatively simple, sterile or hostile conditions, dependent on the resources available.

For instance, given high sediment loads, modified and unstable banks, and no riparian vegetation, the resulting habitat will be simple glide (low gradient, little diversity of depth) with no cover. This will be of little use to fish, except as a travel corridor. On the other hand, highly complex aquatic habitat derived from overhanging banks, with large woody debris accumulations in the low water channel, and more trees standing on the banks, will support numerous fish as there is enough room for each to have their own “apartment” complete with shade, cover from predators, and a supermarket of food drifting by within reach.

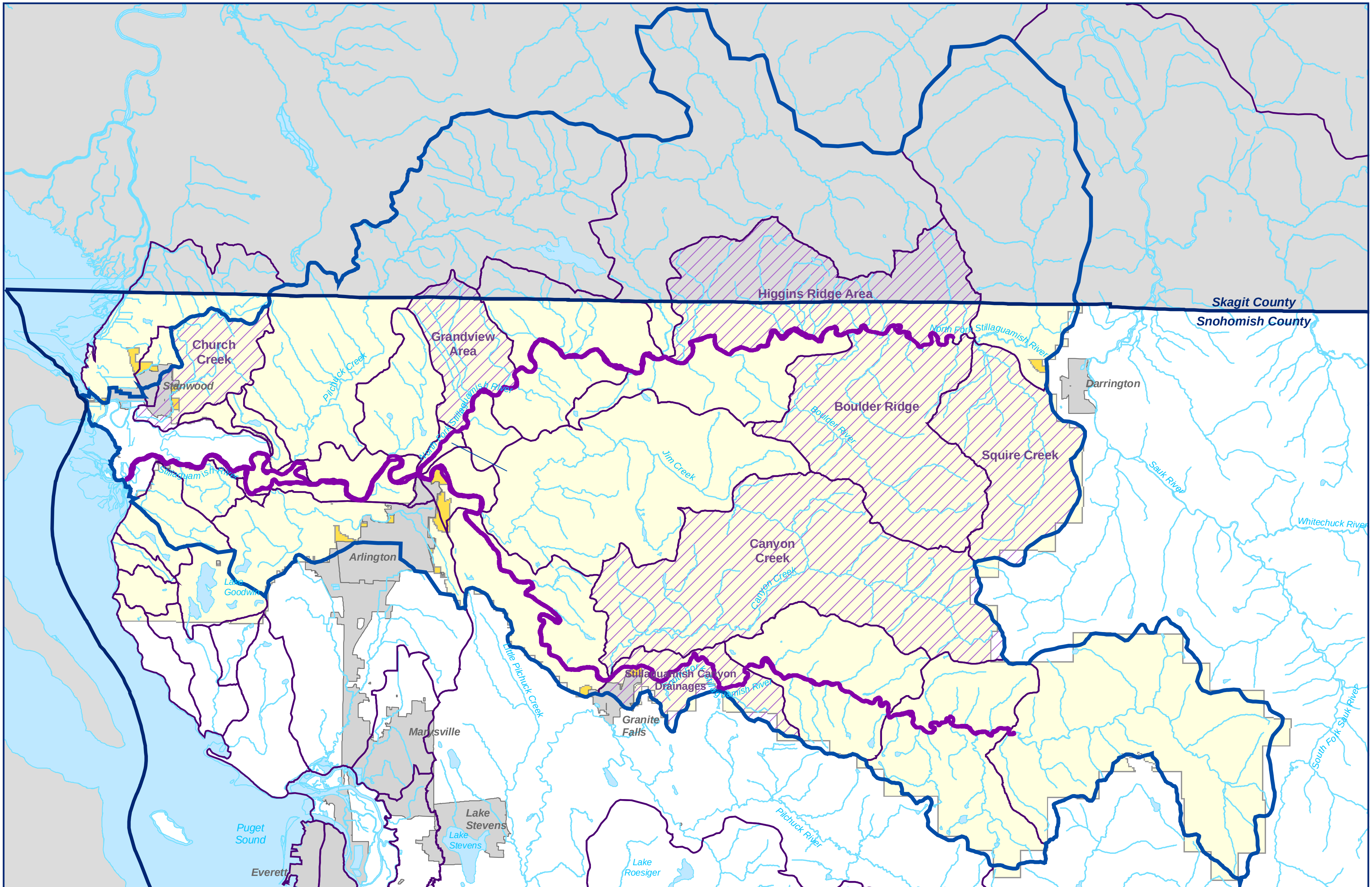

Figure 2.3.4-1 Habitat & Big River Surveys in the CWD

- Big River Survey
- Habitat Surveys
- Stillaguamish Basin
- Subbasins
- Rivers & Streams
- Lakes & Bays
- Cities
- Stillaguamish CWD
- Stillaguamish CWD UGA

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The particular combination of physical factors that make up a particular habitat (e.g., is it a pool, riffle, or glide; what is the frequency of woody debris) largely, but not totally, determines the predominant uses of that habitat by fish. Salmon and other salmonids each have their own particular needs for each habitat type (e.g., Healy 1991), but in general, spawning occurs in gravel and small cobble-bedded reaches where the gradient is relatively low (<four percent). Rearing habitat is located along streambanks and bar edges, backwater pools, beaver ponds, smaller tributaries, side channels and oxbows. The critical elements for rearing habitat are low velocities, plentiful food, and protection from high temperature and predators.

As hydrologic and other forces play out over the seasons and years, each river cuts and/or builds a floodplain. This floodplain is the savings account of wood, vegetation, gravel and biota where the river sometimes makes withdrawals, making deposits in its opposite number. Therefore aquatic habitat is intimately linked to and depends on its floodplain, the zone over which the river channel migrates over time, to provide future complexity, spawning habitat, backwater pools, and streamside vegetation. Like wetlands, natural floodplains have been modified and disconnected in places from their rivers due to human activities and development. Where a river is disconnected from its floodplain--whether by pasture, levee, state highway or residential subdivision--supplies for aquatic habitat are unavailable, so aquatic habitat quantity and quality declines.

Aquatic Habitat Quality Indicators and Criteria

To evaluate the productivity of salmonids in various aquatic habitats, several indicators of physical habitat have been researched to determine their effect on salmonid growth, yield, density, use, and survival. Methods have been developed (Hankin and Reeves 1983; Snohomish County Public Works 2005, 2006) to consistently measure a small set of attributes that yields information in a form that can be compared with regional criteria developed by Washington Forest Practices Board (1997) and National Marine Fisheries Service (1996).

Additional information collected allows the identification of habitat according to the Ecosystem Diagnosis and Treatment Model. This facilitates using empirical data to help predict the results of future habitat restoration actions, as well as supplying inputs for use in the All H-Analyzer model. This model uses information produced by Ecosystem Diagnosis and Treatment Model in combination with harvest and hatchery practices to help determine the effects of actions, protections, and practices on salmon populations.

Wadable Stream Habitat Criteria

The short list of habitat indicators for salmonid productivity includes the frequency of large woody debris, the frequency or percent area covered by pool habitat, bank stability, bank modifications (revetment, etc.), and the amount of surface fines covering spawnable gravel or cobble Table 2.3.4-2 presents the indicators of fully functioning aquatic habitats in smaller, wadable, streams. This approach provides a concise overview of stream habitat conditions and is adequate for the purposes of this report. Riparian corridors, which provide the structure for stream habitat, are also evaluated in the second part of this section.

Table 2.3.4–2 Stream Habitat Indicators and Criteria

Source/ Indicator	Pool Freq.	Pool Area	Large Woody Debris Freq.	Woody Debris Freq. (pieces/ channel width)	Bank Instability	Bank Modifi-cation	Surface Fine Sediment
Bjornn and Reiser 1991							12%
Bilby and Ward 1989				2.0			
NMFS 1996	~20/ mile	50%	80 pieces/ mile		<10%	<10%	

Aquatic Habitat Survey and Sampling

Declines in salmonid populations, Endangered Species Act (1973) listing of Chinook salmon and bull trout, and proposed listing of steelhead in the Stillaguamish Clean Water District have led to efforts to measure and evaluate the district's aquatic habitat. Quantitative, repeatable measures of aquatic habitat have been made by tribal and county staff in different streams over the last 15 years. Early efforts were focused on watershed analysis of state and private forest lands, including Deer Creek in 1992. In the mid-1990s, a partnership effort carried out by Tulalip tribal staff and others measured and evaluated numerous streams for their limitations for coho salmon production (Pess et al. 1999). Snohomish County performed wadable habitat surveys from 2000-2002; locations can be seen in Figure 2.3.4-1.

Aquatic Habitat Status in Wadable Streams

The status of aquatic habitat will be presented via tables of data for alluvial channels collected using documented, repeatable surveys. The focus will be on pool area and woody debris frequency. Bank conditions (hardening, stability) and sediment will be discussed as available.

Comparing the results of the 1992 survey of Deer Creek (Table 2.3.4-3) with regional criteria back in Table 2.3.4-2 shows that percent pool area and woody debris (measured in pieces per channel width) fall far below that required for fully functioning aquatic habitat for salmonids. A century of clearing, building roads, forestry, agricultural practices, and development in riparian areas have removed 40-85 percent of woody debris needed by these rivers and streams. This and other factors have reduced the pool area in the Deer Creek Subbasin to 35-45 percent of what salmonids need.

Table 2.3.4-3. Physical Aquatic Habitat Conditions of Deer Creek in 1992

Reach	Total Length (miles)	AVE BFW (miles)	Total Area (miles^2)	Percent Pool Area	Woody Debris/ Channel Width (cw) (pieces/cw)
1	2123.00	10.53	22,351.21	21.77	0.31
3	1404.50	13.54	19,020.94	19.07	1.20
4	2074.00	12.23	25,360.17	20.46	0.41
5	2537.00	9.39	23,819.16	17.53	0.50
6	1617.00	9.06	14,650.02	22.09	0.68
Totals	**9755.5**		**105,201.49**	**20.05**	**0.59**

Pess et al. (1999) surveyed numerous stream segments during low flows in 1995 and 1997. This broad-scale project to survey conditions largely in smaller streams nonetheless included numerous reaches in the Clean Water District and adjacent lands. Summary results are found in Table 2.3.4-4.

Table 2.3.4-4. 1995 and 1997 Aquatic Habitat Conditions for Various Subbasins

Subbasin	Percent Pool Area	Mean Pieces of Woody Debris/Channel Width
Harvey Armstrong Creek	18.0	0.5
Jim Creek	34.5	3.1
Gold Basin	60.0	4.5
French-Segelsen	26.6	2.5
Deer Creek	18.0	6.2
Lower North Fork	32.0	0.3
Lower Pilchuck Creek	45.0	0.3
Lower Stillaguamish	54.4	0.1
Lower South Fork	25.5	0.3
Middle North Fork	31.3	3.2
Portage Creek	45.3	0.8
Robe Valley	47.0	1.8
Squire Creek	49.8	2.8
Lower Canyon Creek	31.5	4.8
Upper Canyon Creek	38.0	0.0
Upper North Fork	27.8	1.9
Upper South Fork	30.3	4.7

Source: Pess et al. 1999

In the above table, pool area percentages ranged from a low of 18 percent in Deer Creek and Harvey Armstrong Creek subbasins to a high of 60 percent in Gold Basin subbasin. All but two of the subbasins fell below the target of 50 percent of the aquatic habitat being pools to function fully for salmonids. Notably, eight of the subbasins had more than 34 percent pool area; the remaining subbasins would be classified not suitable for pool habitat.

Data on the frequency of large woody debris per channel width shows wide variation across the subbasins -- from zero pieces in Upper Canyon Creek to a high of 6.2 pieces/channel width in Deer Creek. Only eight of the 17 subbasins (about half) meet the requirement of two pieces/channel width to function productively as fish habitat.

This demonstrates two factors to keep in mind when examining this data. One factor is that Upper Canyon Creek has some of the highest values for riparian forest cover and mature evergreen forest (see discussion below). The area was harvested in the early 1980's through the early 1990's, but the cut was patchy. It leaves the question of the destination of the remaining large woody debris and demonstrates that strict correlations between forest cover and in-channel large woody debris frequency cannot be drawn at the reach scale.

A second factor is exemplified in the case of Deer Creek. Deer Creek was surveyed in 1992 and little large woody debris was found in the reaches surveyed. Significantly more was found in the

1995/1997, however, this survey did not necessarily look at the same areas. Without a statistically based sample or revisit of the exact same reach it is hard to compare one year's results with another. Snohomish County staff were not involved in these earlier surveys and the information provided in the resulting reports of these activities has not been analyzed to determine whether exact, similar or comparable reaches were surveyed.

Beginning in 2000, Surface Water Management staff surveyed aquatic habitats in wadable streams in the Clean Water District using an explicit protocol that was highly precise. An attempt to survey at least 25 percent of the alluvial reaches in these subbasins provides some basis for assuming that the survey results represent the current status of aquatic habitat for salmonids, until newer data is available.

An evaluation of this data is presented in Table 2.3.4-5 for seven subbasins. Squire Creek, Higgins Ridge (now part of French-Segelsen and Middle Fork subbasins), Canyon Creek, and Boulder River subbasins were surveyed in 2000. Stillaguamish Canyon and Grandview (now part of Lower North Fork subbasin) subbasins were surveyed in 2001. Boulder River and Church Creek subbasins were surveyed in 2002.

Table 2.3.4.-5. Aquatic Habitat Surveys in Wadable Streams since 2000

Measurement (criteria)	Squire Creek	Higgins Ridge	Canyon Creek	Boulder River	Stillaguamish Canyon	Grandview	Church Creek
Surveyed length (km)	3.5	3.8	8.7	1.9	1.28	0.98	3.9
Total channel length (km)	17.5	15.0	31.6	4.8	2.99	3.18	15.3
Mean bankfull width, CW (m)	24.4	8.9	21.4	28.7	3.8	4.4	5.3
Total pool surface area (50%)	**39.4**	**9.6**	**18.5**	**10.6**	**88.8**	**50.2**	**41.4**
LWD frequency (2 pieces/cw)	**1.65**	**0.4**	**1.2**	**1.79**	**0.09**	**0.67**	**0.57**
Bank instability (<10%)	**11**	**13**	**15**	**9.2**	**8.7**	**4.9**	**1.7**
Surface fine sediment <6.3 mm 12%)	**6**	**15**	**12**	**5**	**61**	**19**	**11**
Mean bank hydro-modifications (<10%)	**n/a**	**n/a**	**n/a**	**n/a**	**0.9**	**0**	**0.1**

An evaluation of the data shows that in general, pool area percentage (total pool surface area) is low (only two of seven subbasins meet the 50 percent criteria). This negatively affects both adult salmonid migration and holding, and juvenile rearing capacity. Woody debris frequency ranges from a low of 0.1 to 1.8 in the surveys since 2000 and thus none of these subbasins meets the regional criteria of two pieces/channel width for suitable woody debris frequency. This adversely affects adult and juvenile salmonid cover from predators, shade cover, and the structure of the streams that contribute to hydraulic and habitat diversity and complexity. Streambank instability ranged from 1.7 to 15 percent unstable banks. Although some of the subbasins exceeded the ten percent limit, the range is indicative of good stability in the reaches surveyed.

Where bank modification data was collected in three of the subbasins, the values indicate little influence from hardened banks in the surveyed reaches. Surface fine sediments were generally low (15 percent or less) with four of the seven subbasins falling at or under the regional criteria of 12 percent or less. Of most concern is the very high fine sediment levels found in the tributaries of the South Fork in the Stillaguamish Canyon Subbasin (immediately upstream of Granite Falls).

Aquatic Habitat Status in Large Rivers

Since larger streams, or rivers, are typically not possible to survey by wading, another set of regional criteria was promulgated by the National Marine Fisheries Service (1996) and others to evaluate larger river (non-wadable) habitats, as shown in Table 2.3.4-6.

Table 2.3.4-6. Large River (Non-wadable) Physical Habitat Evaluative Criteria

Measured Characteristic	NMFS Pathways and Indicators = "Properly Functioning"	NMFS Pathways and Indicators = "At Risk"	NMFS Pathways and Indicators = "Not Properly Functioning"
Pools	Meets pool frequency standards (23 pools/mile @ W_{bf} = 75'; 18 pools per mile @ W_{bf} = 100') and meets large woody debris (LWD) recruitment narrative criteria (see below)	Meets pool frequency standards (23 pools/mile @ W_{bf} = 75'; 18 pools per mile @ W_{bf} = 100') and does not meet large woody debris (LWD) recruitment narrative criteria (see below)	Does not meet pool frequency standards (23 pools/mile @ W_{bf} = 75'; 18 pools per mile @ W_{bf} = 100') and does not meet large woody debris (LWD) recruitment narrative criteria (see below)
Pools (STAG, 2002)	Pool habitat is > 50% of the low flow surface area	Pool habitat is 35-50% of the low flow surface area	Pool habitat is < 35% of the low flow surface area
Large Woody Debris	>80 pieces/mile (50 pieces/km), >24" (60 cm) in diameter, >50 feet (15.2 m) in length, and has potential sources of woody debris for recruitment	>80 pieces/mile (50 pieces/km), >24" (60 cm) in diameter, >50 feet (15.2 m) in length, and does not have potential sources of woody debris for recruit-ment	<80 pieces/mile (50 pieces/km), >24" (60 cm) in diameter, >50 feet (15.2 m) in length, and does not have potential sources of woody debris for recruitment
Bank Stability	On average, <10% of banks are actively eroding	On average, 10-20% of banks are actively eroding	On average, > 20% of banks are actively eroding
Bank Modifications	Shoreline hardening or overwater structures affect <10% of shorelines	Shoreline hardening or overwater structures affect 10-20% of shorelines	Shoreline hardening or overwater structures affect >20% of shorelines

Sources: National Marine Fisheries Service 1996; Stillaguamish Technical Advisory Group 2002

Haas et al. (2003) reported the results of a 2002 low water survey of bank conditions and physical habitat in the North Fork, lower South Fork and Mainstem Stillaguamish Rivers (non-wadable habitats) as shown in Table 2.3.4-7. This data was summarized by larger reaches and evaluated against the large river criteria described in Table 2.3.4-6 above.

Table 2.3.4-7. 2002 Large River Summary of Pool Area, Woody Debris Frequency and Streambank Conditions by Subbasin

Subbasin	Percent Pool Area	LWD Frequency (pieces/km)	Modified Banks (%)	Unstable Banks (%)
French-Segelsen	37.9	5.2	14	25
Middle North Fork Stillaguamish	15.3	0.5	13	19
Lower North Fork Stillaguamish	24	0.7	16	12
Lower South Fork Stillaguamish	28.7	0.8	14	9
Lower Mainstem Stillaguamish	46.4	0.5	53	11
All Reaches	**n/a**	**n/a**	**26**	**13**

The 2002 data shows pool area percentages range from 15 to 46 percent, none of which can be considered to support fully functioning salmonid habitat. More important however are the large woody debris frequencies, which at best, are only ten percent of the regional criteria for fully functioning aquatic habitat for larger rivers. The length of modified banks in each of the subbasins also exceeds regional criteria, but nowhere as much as in the Mainstem Stillaguamish Subbasin (Arlington to Hat Slough). Here more than half the length of the riverbank is diked or revetted with large rock.

These artificial structures greatly simplify aquatic habitat in this reach. The structures are linear and smoothly sloped so they provide for no habitat or hydraulic diversity; no vegetation is allowed to grow on these structures, so the aquatic habitat here lacks predator and shade cover as well. This is not conducive to high quality juvenile rearing habitat that might be obtained and that certainly existed pre-development. Unstable banks are mostly a problem in the middle and upper North Fork reaches. This is thought to be the result of timber harvesting that has been hypothesized to have affected the hydrology (Pess et al. 1999) and the removal of wood from streams where it serves to protect banks.

The preceding has been a discussion of the current status of the North Fork and Mainstem Stillaguamish River. No subsequent surveys have been performed. The current status of the South Fork is found in Table 2.3.4-8; the data was collected during low flow in 2006.

Table 2.3.4-8. 2006 Summary Values for Lower South Fork Stillaguamish River Reaches

Subbasin	Percent Pool Area	Woody Debris Frequency (pieces/km)	Modified Banks (%)	Unstable Banks (%)
Lower South Fork Stillaguamish	27.5%	0.93	10.1	19.5
Reach 1	19.0%	0.55	22.9	35.6
Reach 2	33.2%	1.63	1.1	16.2
Reach 3	27.3%	0.33	8.8	13.3

The percentage of pool areas in these South Fork reaches remains low, as in the North Fork and Mainstem, and large woody debris frequency remains extremely low (0.55 to 1.63 pieces per kilometer or about three percent of regional criteria), putting these reaches in the "not functioning properly" category. The overall modified banks percentage is at the maximum value for "fully functioning" aquatic habitat; however, this represents an aggregate value, as the value at Reach 1 is at 22.9 percent. The data on unstable banks in all three reaches is between 13 and 35 percent, which puts these reaches mainly in the "at risk" category.

2.3.4.1B Trends in Aquatic Habitat

Stream Habitat

The only subbasin for which a legitimate trend may be ascertained is Squire Creek. Other subbasins either were not surveyed in multiple years or changes in subbasin boundaries (done in 2001 to more closely resemble watersheds of a similar size) do not allow direct comparisons. Squire Creek Subbasin's pool area decreased from 49.8 percent in 1995 to 39.4 percent in 2000. This would appear to be a loss of approximately ten percent, but more importantly it moves the subbasin's rating from "fully functioning" to "at risk", according to the National Marine Fisheries Service (1996) guidelines. Woody debris frequency also dropped from a healthy 2.8 pieces per channel width to 1.65 pieces per channel width. Again, this decrease moves the subbasin from a fully functioning aquatic habitat to one at risk. There may be one or more reasons for this change, including clearing in advance of development, private or state timber harvest, poaching of in-channel wood for firewood, etc.

Large River Habitat

Pool area and large woody debris frequency summary data from 2006 agrees quite nicely with the earlier data from 2002. Thus, the short term trend is that these measures of aquatic habitat conditions are holding steady, which, due to the lack of functioning habitat indicated by these measures, is not good news.

Interestingly, there has been a decrease in modified banks and an increase in unstable banks. The decrease in modified banks could be related to 2003 flooding that affected structures in the lowest and uppermost reaches in this subbasin. This could also be the cause of the increase in unstable banks.

However, this habitat is also severely low in large wood. Large woody debris in rivers functions hydraulically as roughness. Manning's equation tells us that increased roughness means decreased velocity. Decreased velocity means decreased stream power. Decreased stream power means less erosive force applied to stream banks. Therefore, at least theoretically, severe flooding in streams and rivers with little to no woody debris to serve as roughness will erode both modified and natural banks.

2.3.4.1C Problems and Gaps

Explained below are the existing problems regarding aquatic habitats, as well as any gaps in data or analysis, and gaps in SWM's programs regarding aquatic habitat management.

Surveys of Aquatic Habitat Conditions Needed

There are numerous gaps in our knowledge of specific aquatic habitat conditions in specific reaches located in the Stillaguamish Clean Water District. Field surveys are expensive and the collection of data has not enjoyed constant political support. The limited number of subbasins Snohomish County staff have been able to survey was a result of organizational refocusing on capital projects. There is also no time table for revisiting the Stillaguamish's North Fork or Mainstem reaches.

Fish-specific Surveys Needed

The 1995/1997 survey was oriented toward coho salmon habitat. This was prior to the ESA-listing of Chinook salmon. A subbasin survey program was restarted in 2006, and data was collected in Lower Pilchuck Creek; however, at the current pace of activity, completing the rest of only Chinook salmon habitat (e.g., Jim Creek), and revisiting other wadable reaches, may take many years.

Data Analysis Needed

Beyond a wadable stream survey planned as a part of SWM's Monitoring and Adaptive Management project, a next step might be to analyze the data at a reach level and compare it to land cover to see broadscale predictors exist that than can estimate field aquatic habitat conditions well enough to better prioritize field surveys and/or capital projects. Such an effort was made during the Drainage Needs Report effort (2002) and some interesting relationships were found in developing a multimetric model.

Determine Effectiveness of Protection Measures

Since 1991, the Northwest Forest Plan, Snohomish County Comprehensive Plan and Forest and Fish Report have all included measures to try to protect aquatic habitat. Without further surveys we will not know for sure if these are working. These protective measures were all instituted by 2000 and this makes the Snohomish County surveys displayed above a good initial data set. Finally, it is not known whether habitat restoration projects are keeping pace with habitat-degrading activities (e.g., road construction, drainage conveyance, streambank stabilization projects) until such surveys are performed.

Agency Collaboration Needed

Also possible are collaborative efforts among the many agencies with jurisdiction or interest in the aquatic habitat of the Stillaguamish Clean Water District to combine staff, equipment and funds to facilitate performing surveys in priority areas.

2.3.4.2 RIPARIAN CORRIDORS

Riparian areas are those areas in and adjacent to streams that provide habitat for numerous species from tiny mosses to towering trees, salamanders to salmon, and bugs to black bear. The riparian area is the structure within which aquatic habitat exists and a constant flow of water, nutrients, organic matter, mineral matter and critters moves between the two.

2.3.4.2A Status of Riparian Corridors in the Clean Water District

Riparian corridors are found throughout the rivers and streams of the Clean Water District. However, riparian corridors in many locations have been substantially altered through historical activities in logging, agriculture, and development. Most of the impacts to riparian zones in the Stillaguamish Watershed have been caused by the following: deforestation; roads and railroads; conversion to agricultural and residential areas; dike, levee and revetment installation; livestock grazing; and noxious weeds. (Stillaguamish Implementation Review Committee 2005).

Federal and state forest lands, which account for slightly over 50 percent of the Stillaguamish Watershed area, currently operate under guidelines which serve to protect threatened and endangered species. Activities on other lands in the Clean Water District are under Snohomish County jurisdiction, and are subject to county and state regulations.

Riparian Functions

Riparian ecosystems perform a number of important functions that affect the quality and quantity of aquatic habitat. A properly functioning riparian forest provides shade, cover, and nutrient input/uptake; stabilizes stream banks; controls sediment; attenuates flooding; and contributes large woody debris and other forms of organic matter. Additionally, riparian vegetation provides a filter that reduces the transport of fine sediment to the stream. Riparian vegetation provides shade and an insulating canopy that moderates water temperatures in both summer and winter. Other benefits include habitat for terrestrial wildlife and improvement to water quality. These functions are impaired as riparian forests are cleared or otherwise altered. (Stillaguamish Implementation Review Committee 2005).

Riparian Conditions

Riparian areas in the Stillaguamish Clean Water District display many different characteristics pre- and post-development. Pre-development riparian conditions were dominated by coniferous trees in tributary basins, by both coniferous and deciduous stands along the North and South Forks and by deciduous forest in the Mainstem (Pollock 1998, Pollock and Kennard 1998). Natural disturbances such as fire, landslides and floods created a mosaic of seral stages (i.e., bare ground, grass, shrubs) scattered across ridges, steep slopes and floodplains that likely occupied 15 to 30 percent of the landscape at any one time. Native trees such as western hemlock, Douglas fir, western red cedar, Sitka spruce grew to more than 200 feet tall in much of the riparian area, mixed with shorter lived deciduous cottonwood, maple and alder trees (Pollock and Kennard 1998).

Post-development riparian conditions include many areas of built environment (roads, buildings, dikes, parking lots), large areas cleared for agriculture, and areas where forestry is the “land use,” but where the forest has been harvested and many years will pass before the new forest begins to emulate the old. The built environment is concentrated along major transportation corridors and within the Urban Growth Areas of Stanwood, Arlington, Granite Falls and Darrington. Agricultural clearing has taken place mostly in the Mainstem, the North Fork upstream to Oso, and the South Fork upstream to Granite Falls.

Forest Cover in Riparian Areas

In 2003 Snohomish County completed an initial land cover classification of conditions from 2001 as shown in Figure 2.3.4-2 (Purser et al. 2003). This effort was repeated to derive a similar picture from an earlier time (1991), to make comparisons (Simmonds et al. 2004). To aid in evaluating riparian conditions, two methods were included. First, the cover classes themselves were developed to help determine different age classes of trees, and a specific geography was delineated that approximated riparian zones. Using ancillary data such as mapping stand ages in Forest Service administered lands, Mature (>100 years old) and Medium (27-99 years old) evergreen forests were classified; a Small Trees and Shrubs class lumped the young, hydrologically immature stands (Christner and Harr 1982) of both deciduous and coniferous trees in with shrubs.

Second, a streamside "buffer" was created in geographic information system technology that roughly includes the area within 300 feet on each side of the stream. This zone was named the 'nearstream area' to distinguish it from both uplands and riparian areas, which are ecological classifications. For the purpose of this analysis however, it can be assumed that this is also the riparian area (Pollock and Kennard 1998, Spence et al. 1996, National Marine Fisheries Service 1996). The 2001 data will be discussed in terms of current riparian condition. The changes in riparian cover from 1991 to 2001 will be discussed later in the trend section.

Current (2001) Riparian Conditions

To evaluate riparian conditions in a broad sense we rely on two calculated summary values, 'total forest cover' and 'total impervious area'. A third measure, "mature evergreen forest", can also be useful in that this forest class most closely resembles "Old Growth Reserves" used as criteria for riparian function by the National Marine Fisheries Service (1996). Total riparian forest cover should exceed 70 percent to provide the shade and predator cover, large woody debris, root-strength, food supplies, and hydraulic and habitat diversity necessary for the productive rearing of juvenile fish in streams. This high degree of forest cover also minimizes fine sediment inputs to ensure high survival-to-emergence for fish eggs, and provides the "tools" needed to create productive spawning, migration/holding, and rearing habitat.

Total impervious area must remain very low to maintain biological productivity. The National Marine Fisheries Service (1996), while not identifying an impervious area criteria, does indicate that watersheds with a road density of greater than two miles per square mile are not providing properly functioning aquatic habitat. Klein (1979), Booth and Jackson (1997), Booth and Reinelt (1993), Horner and May (1998), May et al. (1997), and numerous others agree that by the time a subbasin has as little as ten percent impervious area, its biology has already suffered to the extent that species composition has changed and biodiversity reduced due to habitat and water quality degradation. Thus while Booth et al. (2002) contend that four percent impervious area is nothing to worry about, they are discussing the negative affects of impervious area in subbasins that have 65 percent or more forest cover. In the Stillaguamish Watershed, subbasins with four percent or more impervious area have less than 35 percent forest cover and thus are less resilient to the ongoing effect of increased stormwater runoff.

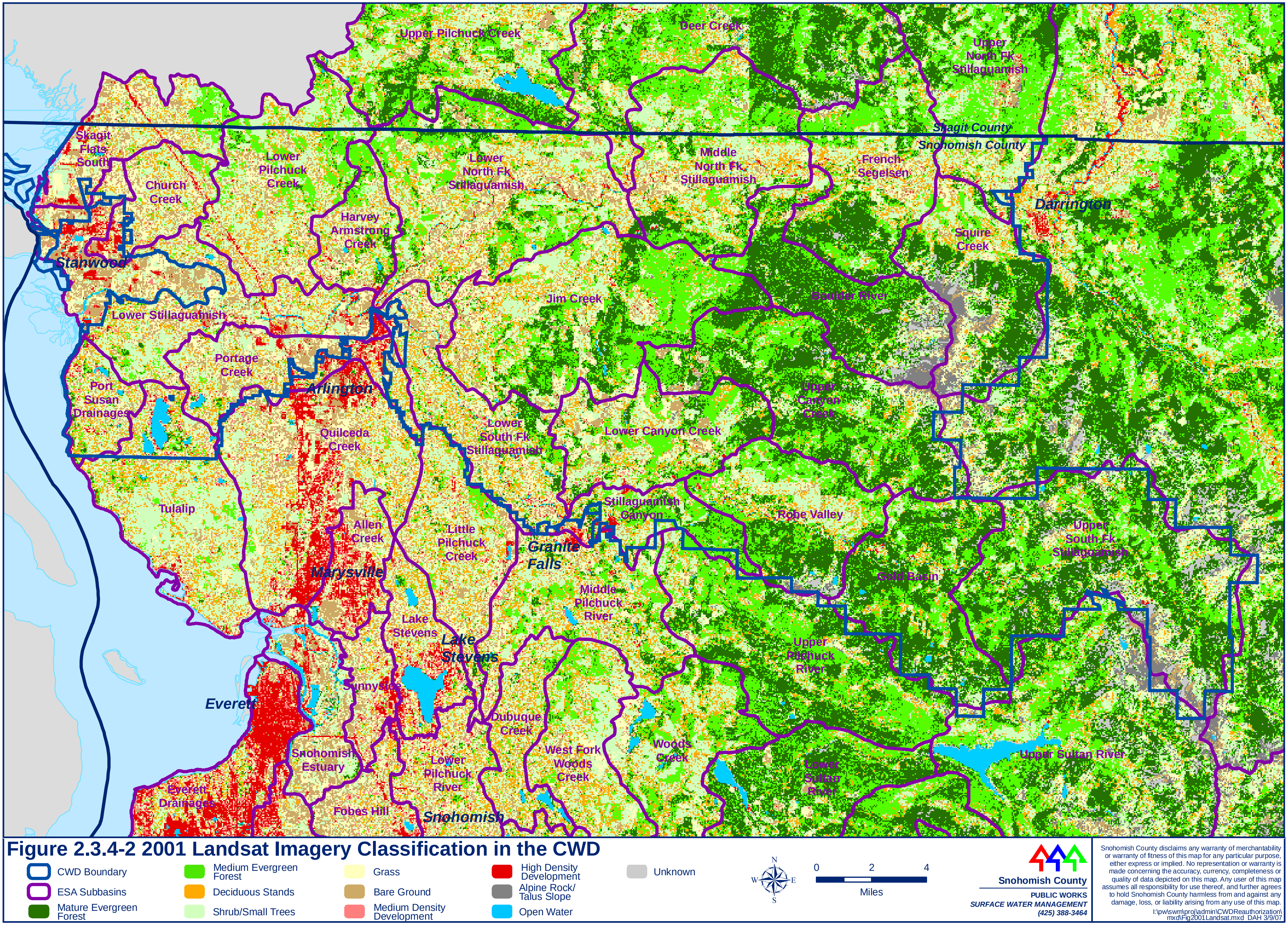

Figure 2.3.4-2 2001 Landsat Imagery Classification in the CWD

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Seven CWD subbasins have nearly 70 percent or greater total forest cover in their riparian areas (Table 2.3.4-9). Boulder River, Deer Creek, Upper Canyon Creek, Stillaguamish Canyon, Gold Basin, Upper South Fork and Upper North Fork subbasins all have more than 66 percent total forest cover. These same subbasins have 28-50 percent mature evergreen forest. They would all be considered properly functioning for provision of salmonid habitat (National Marine Fisheries Service 1996). All but Stillaguamish Canyon are partly or wholly managed by the Forest Service under the provisions of the Northwest Forest Plan.

Table 2.3.4-9. Riparian Land Cover in 2001 (in percent)

Basin/Subbasin	Total Forest Cover	Mature Evergreen forest	Total Impervious Area
Puget Sound Coastal Basin			
Port Susan Drainages	34.07	9.89	9.89
Stillaguamish Watershed			
Mainstem Stillaguamish			
Lower Stillaguamish	16	3	8.1
Church Creek	20	1	5.4
Harvey Armstrong Creek	39	4	1.35
Lower Pilchuck Creek	36	3	1.35
Upper Pilchuck Creek	54.55	14.14	1.36
Portage Creek	19	1	7.65
North Fork Stillaguamish			
Lower North Fork Stillaguamish	38	6	1.35
Middle North Fork Stillaguamish	48	10	1.35
Upper North Fork Stillaguamish	77	33	0
Boulder River	69.79	37.5	0
Deer Creek	66.67	28.28	2.27
French-Segelsen	50	13	0.45
Squire Creek	55	16	0.45
South Fork Stillaguamish			
Upper South Fork Stillaguamish	78.79	42.42	1.36
Lower South Fork Stillaguamish	34.34	9.09	5.45
Gold Basin	79.38	50.52	0.93
Jim Creek	57	16	0.45
Lower Canyon Creek	55.56	17.17	1.82
Robe Valley	63.64	26.26	1.36
Stillaguamish Canyon	72.45	32.65	2.3
Upper Canyon Creek	76.77	40.4	0

Seven other subbasins -- Upper Pilchuck Creek, French-Segelsen, Lower Canyon Creek, Squire Creek, Middle North Fork, Robe Valley, and Jim Creek -- have a mix of federal, state, and private forestry activities ongoing. These subbasins have only 48-63 percent total riparian forest cover, which will result in higher stream temperatures, higher sediment loads, reduced large woody debris frequency, and reduced pooling areas for aquatic life.

Five other subbasins -- Port Susan Drainages, Harvey Armstrong Creek, Lower Pilchuck Creek, Lower North Fork, and Lower South Fork -- are a mix of farms and rural residential land uses. These subbasins retain only 34-39 percent of their riparian area forest cover and thus are very challenged to provide stable streambanks, adequate shade and predator cover, food, etc. to maintain high quality aquatic habitat. It is also in this low forest cover group that total impervious area rises above background levels.

In the last group of subbasins (Church Creek, Lower Stillaguamish, and Portage Creek), total forest cover in riparian areas is 20 percent or less and essentially consists of remnant deciduous stands reminiscent of landscaping. These nearstream areas do not provide the tools and resources that streams need to support healthy aquatic habitat. Ditching streams and poor water quality are emblematic of these subbasins. Impervious areas in these subbasins range from five to nine percent. It is in this range the effects of impervious area in riparian zones become more obvious.

2.3.4.2B Trends in Riparian Corridors

Past (1991) Riparian Conditions

As mentioned earlier, the procedure for developing a Stillaguamish Watershed land cover map was repeated as consistently as possible for scenes from 1991 (Table 2.3.4-10). The results indicate some significant changes in both riparian forest cover and impervious area over a mere ten years.

Ten-Year Trend Analysis (1991-2001)

With regard to forest cover an interesting pattern emerges (Table 2.3.4.-11). The nearstream areas in subbasins dominated by federal forest land show little to no loss in forest cover in that ten-year period. The maximum is a seven percent loss (likely all mature evergreen forest according to data) in Upper Canyon Creek, probably due to harvest on private lands within the subbasin. Of the mixed forestry subbasins, Lower Canyon Creek lost more than 13 percent (including ten percent mature evergreen forest) and fell from the ‘highest’ functioning category to the ‘at-risk’ category. Upper Pilchuck Creek also lost ten percent of its forest cover, including approximately five percent mature evergreen forest. These subbasins are both in the path of private forestry and rural residential development.

Many other subbasins lost five to ten percent of total forest cover (French-Segelsen, Jim Creek, Lower North Fork, Lower Pilchuck Creek, Lower South Fork, Lower Stillaguamish, Portage Creek, Squire Creek), predominately from suburban development. Other notable losses include the Church Creek subbasin, which lost nearly one third (9 percent) of its 1991 forest cover (from 29 to 20 percent). The most dramatic change in the Clean Water District was the Port Susan Drainages, which lost more almost 20 percent of its forest cover, dropping from 53 to 34.

Table 2.3.4-10. Riparian Land Cover in 1991 (in percent)

Watershed/Basin/Subbasin	Total Forest Cover	Mature Evergreen forest	Total Impervious Area
Puget Sound Coastal Basin			
Port Susan Drainages	53	14	2.25
Stillaguamish Watershed			
Mainstem Stillaguamish			
Lower Stillaguamish	22	2	4.95
Church Creek	29	1	0.9
Harvey Armstrong Creek	41	3	0.45
Lower Pilchuck Creek	41	3	0.45
Upper Pilchuck Creek	65	21	0.9
Portage Creek	26	1	1.8
North Fork Stillaguamish			
Lower North Fork Stillaguamish	45	7	1.8
Middle North Fork Stillaguamish	52	12	0.45
Upper North Fork Stillaguamish	80	34	0
Boulder River	70.41	39.8	0
Deer Creek	68	31	1.35
French-Segelsen	56	14	1.35
Squire Creek	62	14	0.45
South Fork Stillaguamish			
Upper South Fork Stillaguamish	78	45	0
Lower South Fork Stillaguamish	45	9	0.9
Gold Basin	77.78	55.56	0
Jim Creek	62	19	0.45
Lower Canyon Creek	69	28	0.45
Robe Valley	64	26	0.9
Stillaguamish Canyon	76	34	0
Upper Canyon Creek	84	53	0
Skagit Watershed			
Skagit Flats			
Skagit Flats South	29	2	0.9

A final mention must be made of the number of subbasins and magnitude of forest loss in subbasins that support Endangered Species Act-listed Chinook salmon. Chinook salmon stocks spawn and rear in the North Fork and its tributaries (summer run), and Mainstem Stillaguamish, Pilchuck Creek, and the South Fork and its tributaries (fall run). As table 2.3.4.2-3 revealed, the only subbasins of these offering protection for salmonids -- from a riparian vegetation standpoint -- are in the upper South Fork (Gold Basin, Upper South Fork). Ironically, Canyon Creek's riparian area in the South Fork basin suffered an approximate loss of ten percent of forest cover, of which about eight percent was mature evergreen forest. Pilchuck Creek lost approximately seven to eight percent riparian forest cover in both its Upper and Lower subbasins in ten years. The current rate of mature evergreen forest lost in Upper Pilchuck Creek's riparian area will possibly deplete that age class within a couple of decades; mature evergreen forest in the Lower Pilchuck Creek subbasin is already at three percent.

Table 2.3.4.-11. Stillaguamish Total Forest Cover, 1991 vs. 2001 (in percent)

Basin/subbasin	1991 Total Forest Cover	2001 Total Forest Cover	Percent change in Cover	Five Percent or less Reduction inForest Cover in Chinook salmon Subbasins
Upper Canyon Creek	84.00	76.77	-7.23	X
Upper North Fk Stillaguamish	80.00	77.00	-3.00	
Upper South Fk Stillaguamish	78.00	78.79	0.79	
Gold Basin	77.78	79.38	1.60	
Stillaguamish Canyon	76.00	72.45	-3.55	
Boulder River	70.41	69.79	-0.62	
Lower Canyon Creek	69.00	55.56	-13.44	X
Deer Creek	68.00	66.67	-1.33	
Upper Pilchuck Creek	65.00	54.55	-10.45	X
Robe Valley	64.00	63.64	-0.36	
Jim Creek	62.00	57.00	-5.00	X
Squire Creek	62.00	55.00	-7.00	X
French-Segelsen	56.00	50.00	-6.00	X
Port Susan Drainages	53.00	34.07	-18.93	
Middle North Fk Stillaguamish	52.00	48.00	-4.00	
Lower North Fk Stillaguamish	45.00	38.00	-7.00	X
Lower South Fk Stillaguamish	45.00	34.34	-10.66	X
Harvey Armstrong Creek	41.00	39.00	-2.00	
Lower Pilchuck Creek	41.00	36.00	-5.00	X
Church Creek	29.00	20.00	-9.00	
Portage Creek	26.00	19.00	-7.00	
Lower Stillaguamish	22.00	16.00	-6.00	x

A few subbasins saw relatively dramatic increases in impervious area between 1991 and 2001. Port Susan Drainages (Warm Beach, Seven Lakes areas) went from two and one-quarter percent to nearly ten percent hard surfaces, an increase of 340 percent. The Portage Creek (Arlington) subbasin went from almost two to slightly more than seven and one-half percent, a similar increase. The Church Creek (Stanwood) subbasin impervious area increased from less than one to more than five percent, a 400-plus percent jump. Impervious area increased to more than eight percent in the Lower Stillaguamish subbasin (Stanwood, Warm Beach, Arlington). As more development is slated for all these increasingly populated locations, the health of small coho salmon-producing tributaries and their associated riparian areas within these impaired subbasins can be expected to continue to decline.

Even more dramatic losses in forest cover and increases in impervious area have occurred, as might be expected, in places in and adjacent to Urban Growth Areas (Table 2.3.4.-12). Stanwood and Arlington both lost more than 50 percent of their remaining forest cover and increased their impervious surfaces by about 20 percent. Granite Falls lost one-third of its forest cover and nearly tripled its impervious surface area. While this can be expected to occur under current land-use planning regulations and practices, it represents a loss of riparian function that contributes to the larger scale losses in aquatic habitat quality and quantity.

Table 2.3.4.-12. Stillaguamish Urban Growth Area Riparian Cover, 1991 vs. 2001

Urban Growth Area	1991 Percent Forest Cover within Urban Growth Areas		2001 Percent Forest Cover within Urban Growth Areas	
	Total Forest Cover (%)	Total Impervious Area (%)	Total Forest Cover (%)	Total Impervious Area (%)
Arlington	16	16	7	36
Granite Falls	33	8	22	22
Darrington	34	12	31	15
Stanwood	13	10	5	29

The following is a summary of the current riparian cover trends:

- Riparian function has been estimated and evaluated across the Clean Water District using Landsat imagery, land cover classification, and regional criteria
- Approximately one-third of the subbasins in the Stillaguamish CWD have riparian areas with high levels of both total forest and mature forest, as well as very low amounts of impervious area (i.e., healthy riparian areas)
- Approximately one-third of the subbasins have riparian areas with medium levels of total forest, low amounts of mature forest, and low levels of impervious area that are challenged to meet the needs of suitable aquatic habitat
- The remaining one-third of the subbasins have riparian areas with low levels of total forest, token amounts of mature forest and rapidly increasing levels of impervious areas (i.e., provides unsuitable aquatic habitat)
- The subbasins with the largest riparian forest cover losses over the trend period are where private forestry and/or suburbanization occur (Port Susan Drainages, Church Creek, Upper Pilchuck Creek, Lower South Fork, Lower Canyon Creek)
- Some subbasins have riparian areas in which the amount of impervious area appears to be increasing exponentially (Port Susan Drainages, Portage Creek, Church Creek)

2.3.4.2C Problems and Gaps

Explained below are the existing problems regarding riparian corridors, as well as any gaps in data or analysis, and gaps in SWM's programs regarding riparian corridor management.

Up-to-Date Data Needed

The status and trend information is now more than five years old (2001), as the original analysis was done in 2004. It is important to add another data point to determine if these trends are long-term—and if so—are they increasing or decreasing. Toward that end, SWM began a new land cover analysis late last year of 2006 data (LANDSAT imagery). When this is completed (estimated to be Summer 2007), we will then have information less than one year old and it will also show the trend from 1991to 2006.

Monitor Effectiveness of Restoration Efforts

It may be prudent to determine whether near-term and longer-term Clean Water District and/or Snohomish County objectives are being met. Studies could determine if existing programs are increasing riparian forest cover or providing high quality riparian zones in the watershed.

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